स्वातंत्र्योत्तर हिन्दी उपन्यासों में सर्वहारा चेतना

(इलाहाबाद विश्वविद्यालय की डी०फिल० उपाधि हेतु प्रस्तुत)

शोध–प्रबन्ध

शोधकर्ता :
अशोक राम

निर्देशक :
डॉ० जगदीश प्रसाद श्रीवास्तव
हिन्दी विभाग
इलाहाबाद विश्वविद्यालय, इलाहाबाद

हिन्दी विभाग
इलाहाबाद विश्वविद्यालय, इलाहाबाद
सन् – 2001

पूजनीय पिता जी की स्मृति
में समर्पित प्रतीक पुष्पांजलि

प्राक्कथन

साहित्य का सम्बन्ध हमारी भावनात्मक सत्ता से होता है। हमारे जीवन का शाश्वत सत्य भावनात्मक रूप में ही प्रतिबिम्बत होता है। "साहित्य मानव समाज का मस्तिष्क है।" कह कर साहित्य की व्याख्या विभिन्न विद्‌वानों ने की है। साहित्य में जो शक्ति छिपी रहती है। वह तोप, तलवार और बम गोलों में भी नहीं पाई जाती है। आचार्य महावीर प्रसाद द्विवेद्वी साहित्य को समाज का दर्पण ही नहीं मानते, वे साहित्य में समाज की अभिव्यक्त ही नहीं खोजतें बल्कि एक कदम आगे बढ़कर समाज का परिवर्तन और विकास को प्रभावित करने वाली सक्रिय शक्ति के रूप में भी देखते है। साहित्य हमारे जीवन को स्वाभाविक और सुन्दर बनाता है। उसी की बदौलत मन का संस्कार होता है। साहित्य और समाज का अटूट सम्बन्ध है। दोनों के एक दूसरें पूरक हैं, समाज के बिना साहित्य की कल्पना नहीं की जा सकती और साहित्य के बिना समाज के स्वरूप को दृष्टिपात नहीं किया जा सकता।

गद्य की परम्परा की शुरूआत साहित्य के अध्ययन के प्रारम्भ में ही हो गयी थी लेकिन उसका पूर्ण विकास आधुनिक काल में हुआ। गद्य परम्परा में अनेक विधाओं जैसे नाटक, कविता, कहानी और निबन्ध आदि का विकास हुआ इन्हीं विधाओं के एक विधा के रूप में उपन्यास विधा का विकास हुआ। उपन्यास की विधा एक ओर तो गद्य साहित्य निर्माण और विकास की समकालीन विधा है और दूसरी ओर उसका सम्बन्ध, मध्यम वर्ग एवं निम्न वर्ग (सर्वहारा वर्ग) से है। उपन्यास वास्तविक जीवन की काल्पनिक कथा है। प्रेमचन्द के शब्दों में "मैं उपन्यास को मानव जीवन का चित्रमात्र समझता हूँ। मानव चरित्र पर प्रकाश डालना और उसके रहस्यों को खोलना ही उपन्यास का मूलतत्व हैं, "उपन्यास में मानव जीवन का प्रतिबिम्ब हो, घटनाएं श्रृंखलाबद्ध हो, वास्तविकता की सेवा में नियोजित कल्पना हो।"

मिशेल जेराफा ने लिखा है कि "उपन्यास ऐसी कला है, जिसमें मनुष्य सामाजिक एवं ऐतिहासिक दृष्टि से निरुपित होकर सामने आता है।" उपन्यास का स्वभाव ऐसा है कि वह सामाजिक यथार्थ की अभिव्यक्ति से भागकर उपन्यास नहीं रह सकता। लेकिन केवल सामाजिक यथार्थ की अभिव्यक्ति के कारण कोई उपन्यास

कलात्मक कृति नहीं हो जाता। अगर ऐसा होता तो सभी उपन्यासकार प्रेमचन्द होते। प्रेमचन्द की रचनाशीलता का ऐतिहासिक संदर्भ स्वाधीनता आंदोलन था। इनके उपन्यासों एवं कहानियां में रचनाशीलता का लक्ष्य किसानों, आदिवासियों, हरिजनों, स्त्रियों, मजदूरों और दूसरे शोषित दलित जन समुदायों का जीवन है।

स्वातंत्र्योत्तर पश्चात हिन्दी साहित्य पर सामाजिक, राजनीतिक क्रांतियों के परिवर्तनों का गहरा प्रभाव पड़ा हैं, आदर्शवाद के स्थान पर यथार्थवाद अथवा पारम्परिक जीवन मूल्यों की जगह प्रगतिशील जीवन मूल्यों की व्यापक रूप से प्रतिष्ठत हुआ। जिसमें निचली श्रेणी का विस्फोटक रूप उभर कर उपन्यासों के सामने आया, जो सर्वहारा वर्ग से सम्बन्धित था। उपेक्षित अंचलों के चित्रों में उपेक्षित, दीन–हीन, पीड़ित लोगों की पहिचान ही सर्वहारा पहिचान है। वास्तव में गांव और अंचलों का उभार ही मोटे रूप में स्वातंत्र्योत्तर उपन्यास साहित्य की मुख्य धारा है। इस धारा में सर्वहारा वर्ग एक बहुत ही पुष्ट बिन्दु है। और स्वातंत्र्योत्तर हिन्दी कथाकारों ने इस वर्ग का बहुत ही व्यापक सांगोंपांग निरूपण किया है। प्रगतिशील कथाकारों ने भी सर्वहारा को उठानें में योगदान किया है।

प्रस्तुत शोध–प्रबन्ध में " स्वातंत्र्योत्तर हिन्दी उपन्यासों में सर्वहारा चेतना " नामक विषय का अध्ययन आठ अध्यायों में किया गया है।

पहला अध्याय में सर्वहारा : एक स्पष्टीकरण (आशय) का वर्णन किया गया है। जिसमें स्वातंत्र्योत्तर हिन्दी उपन्यासों में सर्वहारा वर्ग के स्वरूपात्मक पक्ष मार्क्सवादी दृष्टिकोण से विश्लेषित किया गया हैं और मार्क्सवाद सारभूततत्व एवं मार्क्सवादी दर्शन का सर्वहारा वर्ग और भारतीय समाज के प्रति क्या दृष्टिकोण है। उसके जो दर्शन रहे हैं, भारतीय सामाजिक परिवेश के लिए कहाँ तक तथ्यत्माक है? उसके दर्शन की अवधारणा क्या है? समाज में वर्ग की अवधारणा और वर्ग संघर्ष की तथ्यात्मकता जो उसने अपने दर्शन की माध्यम से कहीं है, वह भारतीय सामाजिक परिवेश में स्वातंत्र्योत्तर हिन्दी उपन्यासों में कहाँ तक रूपायित किया गया है। आधुनिक भारतीय समाज में सर्वहारा वर्ग की स्थिति क्या रही है? उसका अवलोकन स्वातंत्र्योत्तर उपन्यासों द्वारा कर के भारतीय समाज के सर्वहारा वर्ग के स्वरूप को विश्लेषित किया गया है। मार्क्स और एंजेंल्स के विचारधारा के अनुरूप वर्गविहीन समाज और भारतीय सामाजिक

परिवेश में भारतीय वर्ग व्यवस्था शोषित समाज की स्थिति और आधुनिक भारत में सर्वहारा की स्थिति का भारतीय पिछड़े समाज से विवेचन–विश्लेषण किया गया है।

प्रगतिशील उपन्यासकार प्रेमचन्द, यशपाल, नागार्जुन, अमृतराय, भैरव प्रसाद गुप्त, हिमांशु श्रीवास्तव, भगवती चरण वर्मा, रामदरश मिश्र, मैत्रेयी पुष्पा, कृष्णा सोबती, मृदुला गर्ग, उषा प्रियंम्वदा जैसे उपन्यासकारों ने अपने उपन्यासों में विभिन्न घटनाओं, क्रिया कलापों के माध्यम से सर्वहारा वर्ग के स्वरूपों को व्याख्यायित किया गया है।

दूसरा अध्याय के अन्तर्गत सर्वहारा वर्ग से जुड़े विशिष्ट उपन्यासों का अनुशीलन किया गया है। जिसमें स्वातंत्र्योत्तर काल क्रमागत उपन्यास जैसे पानी के प्राचीर, सोनभद्र की राधा, कब तक पुकारूं, अलग–अलग वैतरणी, सागर लहरें और मनुष्य, बलचनमा, उखड़े हुए लोग, मैला आँचल, झूठा–सच उपन्यासों का सामाजिक राजनीतिक, आर्थिक, सांस्कृतिक आदि परिवर्तनों का अवशीलन एवं अवलोकनार्थ है। इन उपन्यासों के पात्रों में अवयस्क लड़के–लड़कियाँ एवमं महिलाएं, बृद्ध पुरूष वर्ग का आधुनिकता जीवन बोध दिग्दर्शन किया गया है।

तीसरा अध्याय में सर्वहारा वर्ग की आर्थिक समस्याओं का अवलोकन एवं चेतनशीलता का विश्लेषण करते हुए इसमें नये उपन्यासों में सर्वहारा वर्ग की आर्थिक समस्याओं के अन्तर्गत आकलित किया गया है। यह समस्या कैसे उत्पन्न होती है? इसके नियंत्रक तत्व कौन से हैं इस पर प्रकाश डालते हुए सर्वहारा की आपूर्ति में बाधक में निर्धनता का भूमि सम्बन्धी विशेषताएँ, जमींदारी उन्मूलनोंपरान्त भूपतियों का सर्वहारा के प्रति उदित मनोभावों, आर्थिक बिषमता से उत्पन्न सर्वहारा के अन्यांय जीवन मूल्यों पर प्रकाश डाला गया है। इसमें अर्थचक्र की सर्वोन्मुखी समस्यात्मक कोण, उचित पारिश्रमिक की समस्या, भविष्योंमुखी आर्थिक क्षितिज का दृष्टिकोण विवेचित का करने का प्रयास किया गया है।

चौथा अध्याय में हिन्दी उपन्यासों में राजनीति और सर्वहारा वर्ग का प्रतिमान, आयाम के उपन्यास चित्रों को उद्‌घाटित किया गया है। स्वातंत्र्योत्तर उपन्यासों में भारतीय सामाजिक परिवेश में सर्वहारा वर्ग की राजनीतिक चेतना को व्याख्यायित किया गया है। किस प्रकार स्वातंत्र्योत्तरकाल में सर्वहारा वर्ग समाजवादी विचारों से प्रभावित हुआ है। स्वातंत्र्योत्तर हिन्दी उपन्यासों के सन्दर्भ में उभरी नव सर्वहारा संस्कृति अभ्युदय

एवं इस वर्ग से सम्बन्धित विभिन्न राजनीतिक सन्दर्भ को भी विश्लेषित किया गया है। अधिकार बोध की चेतना नें वर्ग संघर्ष के विविध आयामों को प्रश्रय दिया है। सर्वहारा वर्ग की राजनीति में भूमिका दलिय स्थिति के बारे में भी अवलोकन कर स्वातंत्र्योत्तर उपन्यासों के परिप्रेक्ष्य में विवेचित करने का प्रयास किया है।

पाँचवा अध्याय में स्वातंत्र्योत्तर हिन्दी उपन्यास साहित्य के प्रमुख सर्वहारा पात्र–योजना एवं चरित्राकंन को आख्यायित किया गया है। सवर्दा से उपेक्षित पदमर्दित शोषित व्यक्तियों को नारी एवं पुरूष पात्र में बलचनमा, जागला, सुखराम, विरजा, दुखन, जयदेवपूरी, डॉ0 प्राण, गंगा, मलारी, नट नारी प्यारी, बसमतियां, इंजोरिया, पलकी, कनक, तारा जैसे पात्र के माध्यम से आलोच्य कालावधि में जो सामाजिक आर्थिक परिर्वतन हुए है। उसका सर्वहारा वर्ग पात्रों द्वारा बिश्लेषण एवं चरित्र–चित्रण प्रस्तुत किया गया है।

छंठा अध्याय में सर्वहारा वर्ग में सामाजिकता का बोध उपन्यास साहित्य में प्रतिफलन अंकित किया गया है। इसमें स्वतंत्रता पूर्व सर्वहारा वर्ग की सामाजिक शोषक–मूलक परिवेश का मूल्यांकन प्रस्तुत किया गया है। स्वातंत्र्योत्तर सर्वहारा वर्ग की सामाजिक समस्या का प्रतिरूप एवं नये पीढ़ी के नये आयाम समाज में नवीनतम शीलता वर्ग संघर्ष की सामाजिक परिदृश्य, सर्वहारा वर्ग की नव आधुनिकता एवं सर्वहारा चेतना की सामाजिक स्थितियों, उत्पीड़न और शोषण का अवलोकन विश्लेषित किया गया है।

सातवाँ अध्याय में स्वातंत्र्योत्तर हिन्दी उपन्यासों में सर्वहारा वर्ग की सांस्कृतिक आत्मबोधता का वर्णन किया गया है। उपन्यासों में कथाकारों ने अपने कथा के माध्यम से सांस्कृतिक चेतना एवं धार्मिक मान्यताएँ जैसें ईश्वरास्था, देवपूजा, नाना साधनों के प्रति समर्पित एवं विविध आयामों से सम्बद्व किया गया है। समाज का सर्वहारा वर्ग के दुटते–जुडते सांस्कृतिक मूल्यों, पुरानी रूढ़ियों, अन्धविश्वासों का अवलोकनार्थ एवं जीवन मूल्यता और सर्वहारा वर्ग का विन्यास, विवाह संस्था की मान्यताएँ आधुनिक बोधगम्यता का सांगोपांग निरूपण किया गया है। उपन्यासों में विशेष अभिज्ञान के अन्तर्गत सांस्कृतिक अनुष्ठान, नारी नवजागरण, दलितोंत्थान, दलितसाहित्य, संत कबीर,

ज्यातिबा फूले, डॉ0 राममनोहर लोहिया एवं डॉ0 भीमराव अम्बेडकर के सांस्कृतिक जीवन मूल्यों का फलक अन्वेषित करने का प्रयास किया गया है।

आठवाँ अध्याय: उपसंहार में समूचे मूल्याकंन की दिशाओं का स्पष्ट किया गया हैं। युग सन्दर्भ जीवन की परिस्थितियों अन्तर्राष्ट्रीय धरातल पर होने वाली वैचारिक और बौद्धिक परिवर्तन इन सबसे कभी जुड़कर और कभी कट कर हमारा उपन्यास साहित्य आगें बढ़ता रहा है। फिर वह विकास यात्रा आज भी जारी है।

प्रस्तुत शोध प्रबन्ध विद्वद्रेण्य, सत्यनिष्ठ, सूक्ष्मअन्वेषक, श्रद्वेय गुरूवर डॉ0 जगदीश प्रसाद श्रीवास्तव (हिन्दी विभाग, इलाहाबाद विश्वविद्यालय, इलाहाबाद) के कुशल निर्देशन में सम्पन्न हुआ है। पूजनीय गुरूदेव ने आद्यांत शोध प्रबन्ध को साकार रूप देने में गुरूतर दायित्व का निर्वाह किया। इस पुनीत कार्य हेतु आदरणीय गुरूजी के प्रति श्रद्धावनत हूँ।

गुरूवर द्धारा प्रदत्त परामर्श, हार्दिक सहयोग तथा मानसिक सम्बल के सहारे ही यह शोध कार्य अन्तिम चरण तक पहूँच सका है। किन शब्दों में, मैं अपना आभार प्रकट करू! मै स्पष्ट अनुभव कर रहा हूँ कि कहीं–कहीं शब्द हृदयगत भावों की अभिव्यक्त पूर्णतः समर्थ नही होते।

मैं हिन्दी विभाग, इलाहाबाद विश्वविद्यालय, इलाहाबाद के उन सभी गुरूजनों के प्रति विशेष रूप से डॉ0 राजेन्द्र कुमार (विभागाध्यक्ष), डॉ0 मोहन अवस्थी, डॉ0 योगेन्द्र प्रताप सिंह, डॉ0 किशोरी लाल, डॉ0 मालती तिवारी, डॉ0 मीरा श्रीवास्तव, डॉ0 सत्यप्रकाश मिश्र, डॉ0 रामकिशोर शर्मा, डॉ0 शैल पाण्डेय, डॉ0 भूरेलाल एवं विभागीय अन्य प्राध्यापकों के प्रेरणाप्रद व्यक्त्वि के प्रति अपना प्रणति निवेदित करता हूँ, जिनका आर्शीवाद एवं सहयोग मुझ अंकिचन को प्राप्त होता रहा है। ये विद्वत् बिन्दु मेरे लिये सम्बल है।

पारिवारिक सहयोग के बिना कोई कार्य पूर्ण नहीं होता है। शोध कार्य के समय सदैव इसका अनुभव होता रहा है। मेरे ममतामयी पूजनीया माँ श्रीमती फूलेश्वरी देवी का स्नेह एवं आशीर्वाद ही है, जो मुझे आगे बढ़ने की प्रेरणा देता रहा है और बिषम परिस्थितियों में भी मैं उन्ही से होता रहा हूँ। भ्राताओं में अनुज श्री गुलाब चन्द्रा

(एडवोकेट) का समय–समय पर भरपूर सहयोग मिलता रहा है। परिवार के प्रत्येक सदस्य का हार्दिक सहयोग ही था। जिससे गुरूतर कार्य पूर्ण हो सका।

प्रेरणा प्रदायिनी पूजनीया दीदी श्रीमती शान्ती गौतम के प्रति आभार प्रकट किये बिना कैसे रह सकता हूँ जो मुझे शिक्षापथ का थका–माँदा विकल पथिक होने की प्रेरणा, ऊर्जा और हर सम्भव सहयोग देती रहीं एवं स्नेहिला सुश्री अर्चना का अप्रतिम अनुपमेय योगदान रहा है एवं प्रेरणादायिनी सुश्री रेखा (प्रवक्ता, समाजशास्त्र विभाग, लखनऊ विश्वविद्यालय) का जिनकी दृढ़ता, दूरदर्शिता एवं प्रतियोगितात्मक भावना ने मुझे दृढ़ दूरदर्शी एवं प्रतिस्पर्शी होने की प्रेरणा प्रदान की। मैं उनका ऋणीं एवं आभारी रहुगां। भामाशाह सरीखे प्रेरणादायक श्री श्रवण कुमार (जीजा जी) एवं इष्टमित्रों, सर्वश्री तारकेश्वर प्रसाद, व्यासमुनि, मुसाफिर प्रसाद, सच्चिदानन्द, अजित कुमार, नन्द प्रकाश (एडवेाकेट) एवं उमेश कुमार का चिर ऋणी हूँ जिन्होंने अपनी धन की गठरी खोलकर मेरे शोध की आर्थिक बाध्यता को दूर किया। इसके अतिरिक्त विभागीय कर्मचारियों एवं अन्य सगें सम्बन्धियों के प्रति भी आभार व्यक्त करता हूँ जिनका प्रत्यक्ष या अप्रत्यक्षरूप से सहयोग रहा है।

शोध प्रबन्ध की पूर्णता में, हिन्दी साहित्य सम्मेलन, इलाहाबाद, हिन्दुस्तान अकादमी, पब्लिक लाइब्रेरी, विश्वविद्यालय पुस्तकालय, केन्द्रीय पुस्तकालय काशी विश्वविद्यालय बनारस से शोध प्रबन्ध से सम्बन्धित सामग्री प्राप्त हुई। इसलिए मैं वहाँ के अधिकारियों एवं कर्मचारियों को सह्रदय धन्यवाद ज्ञापित करता हूँ।

विनयागत् होकर मैं यह शोध प्रबन्ध प्रस्तुत कर रहा हूँ, मुझे आशा ही नहीं विश्वास है कि विद्धद्जन इसमें हुई त्रुटियों को क्षमा करेगें। यदि प्रस्तुत शोध प्रबन्ध " स्वातंत्र्योत्तर हिन्दी उपन्यासों में सर्वहारा चेतना" के प्रति किंचित् भी ध्यानाकर्षित करता है तो मैं अपना अथक प्रयास सफल समझूगाँ।

विनयावनत् :

अशोक राम

अशोक राम

हिन्दी विभाग

इलाहाबाद विश्वविद्यालय इलाहाबाद

2001

अनुक्रमणिका

पहला अध्याय

सर्वहारा: एक स्पष्टीकरण (आशय)

(क) सर्वहारा का स्वरुपकात्मक विश्लेषण :

मानव समाज के विकास की ऐतिहासिकता पर विश्व के विचारकों एवं दार्शनिकों ने समय–समय पर मानव जगत में कई दार्शनिक मतवाद और विचार धाराओं का सूत्रपात किया है। देश और काल की प्राचीरों को लॉघनें की क्षमता को रखने वाले दार्शनिक सिद्धान्त साहित्य के क्षेत्र में भी अवतरित होते है। कुछ दार्शनिक सिद्धान्त सदा सर्वथा दार्शनिक सिद्धान्त ही बने रहते है तो कुछ और सिद्धांत काल की चेतना को आत्मसात् करते हुए विकासशील होकर अक्षुष्ण रहते हैं। वे युग को प्रभावित करते है और युग उसमें भी प्रभावित हो जाता है। विप्लव के बीच–बीच जिन नए मनुष्यों का जन्म होता है वे मुनष्य विप्लव की महान रचनाएं होते है। जैसे सागर की लहरों में हर उतार के बाद चढ़ाव जरूर आता है, वैसे हर पराजय के बाद चढ़ाव जरूर आता है।

बीसवीं शताब्दी में घटित परिवर्तनों की प्रेरक शक्तियों में सर्वहारा वर्ग का विकसित रूप दिखलाई पड़ रहा है । मार्क्स के अनुसार पूँजीपति एवं सर्वहारा दो वर्ग है । जिसमें सर्वहारा वर्ग स्वाधीनता बाद जागरूक हो गया है इनमें परिवर्तन के लक्षण व्यापक रूप से दिखलाई पड़ रहा है। संविधान में समान अधिकारोपरान्त वर्णव्यवस्था एवं जाति व्यवस्था की संकीर्ण कड़िया टूट रही है। सर्वहारा अपने अधिकारों के लिए लड़ रहा है क्योंकि सर्वहारा में जन शक्ति का सैलाव है जबकि पूँजी पति वर्ग में धनशक्ति है । सम्पूर्ण समाज को अब तक यही अर्थशक्ति नियंत्रित करती रही है। इस अर्थशक्ति को चुनौती देने वाला सर्वहारा वर्ग ही स्पष्टतया समाज में दीखता है।

भारतीय समाज में आर्थिक असमानता, वर्गसंघर्ष मध्यवर्गीय जीवन का शिथिलीकरण, वैयक्तिक तनाव, नये पुराने, आदर्शों और सिद्धान्तों का द्वन्द्व, समाज और व्यक्ति का आपसी वैमनस्य शैक्षणिक प्रणाली के प्रयोग एवं उसमें उत्पन्न कठिनाइयों, शिक्षित नारी का नवीन विकास आदि तत्व क्रियाशील है। समाज में परिवर्तन की दृष्टि से कीर्ति हो रही है, इसमें असंतोष की भावना भूखमरी, बेकारी और सामाजिक विसंगतियों में सम्पूर्ण देश डूबा हुआ है। अनेक विसंगतियों का निराकरण सर्वहारा द्वारा ही किया जा सकता है।

सर्वहारा वर्गीय जीवन में राजनीतिक, सामाजिक, आर्थिक, धार्मिक एवं सांस्कृतिक पक्षों की परिवर्तित एवं पारम्परिक गतिशील एवं स्थिर वास्तविकता तथा तन्जन्य मानसिकता है, इसके अन्तर्गत आधुनिकता बोध की वैचारिक स्वीकारोक्ति समसामयिकता की प्रभाव परिणति एवं सॉस्थानिक परिवर्तनों की क्रियाशीलता विद्यमान है। आधुनिक समाज के विषय में स्तालिन ने कहा है कि "एक श्रेणी उन पूंजीपतियों की है जो कच्चे माल तथा कल कारखानों और फार्मों के मालिक हैं। इसके विपरीत दूसरी श्रेणी उस विशाल सर्वहारा मजदूर वर्ग की है जिसके पास अपनी श्रम शक्ति है कि अतिरिक्त कुछ नहीं है।"

मार्क्स ने वर्गहीन समाज की स्थापना और अपने लक्ष्यों की प्राप्ति के लिए पूंजीवाद के विनाश की अनिवार्यता घोषित की है। पूँजीवाद की समाप्ति के लिए पूँजीवाद से ही उद्भूत सर्वहारा, जो इसी की कब्र खोदता है को अपने दर्शन का आधार बनाया है और कहा कि सर्वहारा को मुक्ति दिलाये बिना दर्शन को चरितार्थ नहीं कर सकता, सर्वहारा दर्शन को चरितार्थ किये बिना अपनी मुक्ति नही कर सकता, मार्क्स ने मुक्ति के महान् आन्दोलन को व्यक्ति और समाज के अन्यान्य क्रम में प्रकट होता हुआ देखा।[1] लासेल ने भी सर्वहारा को प्रधानता देते हुए कहा कि सर्वहारा वह चट्टान है, जिस पर भविष्य में मंदिर का निर्माण होगा। जोरेस ने तो समाजवाद कैसे प्राप्त होगा के प्रत्युत्तर में कहा कि, 'सर्वहारा के विकास से जिसका समाजवाद से अटूट सम्बन्ध[2] है। सर्वहारा वर्ग में किसी वर्ग विशेष का आधिपत्य नहीं रहता। शोषित वर्गों का यह संगठित वर्ग होता है। "बुर्जुआ वर्ग के मुकाबले में आज जितने भी वर्ग खड़े हैं, उन सब में सर्वहारा ही क्रांतिकारी वर्ग है। दूसरे वर्ग आधुनिक उद्योग के साथ ह्रासोन्मुख होकर अन्ततः विलुप्त हो जाते है, सर्वहारा वर्ग ही उसकी मौलिक और विशिष्ट उपज है।

सर्वहारा के माध्यम ये अभिलषित समाजवाद वन आगमन हो सकेगा, ऐसा मार्क्स और उसके अनुयायियों का विश्वास हैं क्योंकि समाज के दूसरे वर्ग अपने स्वार्थों के कारण पूंजीपतियों से आबद्ध रहते हैं। अतएव क्रांति की ज्वाला उनके माध्यम से नहीं आ सकती वे अधिक से अधिक सुधार की बात कर सकते हैं सर्वहारा क्रांति की अधिक

---

1. एशियाई समाजवाद : एक अध्ययन : अशोक मेहता, अनु0 श्यामा प्रसाद प्रदीप, पृष्ठ–116 अखिल भारतीय सर्वसेवा संघ प्रकाशन राजघाट, काशी।
2. एशियाई समाजवाद : एक अध्ययन से उद्धृत, पृष्ठ–95

सुधार की बात कर सकते हैं सर्वहारा क्रांति की सबसे बड़ी विशेषता होगी। समाज को वर्गीय भावना से मुक्त करके साम्यवाद का प्रसार।[1] इन संदर्भों के आधार पर 'सर्वहारा' के विषय में सर्वप्रथम व्युत्पति परिभाषा और स्वरूप के परिप्रेक्ष्य में विचार कर लेना आवश्यक हैं।

16 अक्टूबर, सन् 1972 ई0 को एक सम्मेलन में शराफ रशी दोव द्वारा प्रस्तुत रिपोर्ट में कहा गया हैं कि विश्व पूंजीवाद ने अन्तर्राष्ट्रीय सर्वहारा वर्ग को जन्म दिया। यह जबरदस्त सामाजिक शक्ति थी जिससे यह तकाजा किया गया था कि वह इन्सान के हाथ इन्सान के शोषण को मिटाने, समाज का पूरी तरह संगठन करने तथा तमाम राष्ट्रों की मेहनत कश जनता का एक बन्धुत्व पूर्ण संघ तैयार करने के लिए होने वाले संघर्ष कार्य का नेतृत्व करें।[2]

मार्क्स और एंगेल्स ने समाज के विकास की जिस वैज्ञानिक भौतिकवादी संकल्पना की खोज की, वह कम्युनिस्ट पार्टी का घोषणा पत्र की सम्पूर्ण अर्न्तवस्तु में व्याप्त हैं। पाठक के समक्ष समाज का इतिहास वर्ग संघर्ष के इतिहास के रूप में आता हैं, प्राचीन युग में दासों का स्वामी और दास, सामंतवाद के युग में सामंती भूमिपति और भूदास वे विरोधी वर्ग थे। जो एक दूसरे के जानी दुश्मन थे और एक अन्तहीन संघर्ष चलाये रखते थे, जिसके फलस्वरूप समाज का, क्रांतिकारी रूपान्तर हुआ। दासों पर स्वामित्व वाला समाज खत्म हुआ। तो सामंती समाज बना और सामंती समाज के स्थान पर बुर्जुआ समाज बना, जिसमें दो मूल विरोधी वर्ग होते है। 'बुर्जुआ वर्ग' और 'सर्वहारा'। "इसलिए किसान", मार्क्स ने लिखा "शहरी सर्वहारा को, जिसका काम पूंजीवादी व्यवस्था को उलटना है, अपना स्वाभाविक मित्र और नेता पाते है"।[3] किसानों के बड़ें समुदायों की सहायता से "सर्वहारा क्रान्ति वह समवेत स्वर प्राप्त करेगी, जिसके बिना उसका एकल गीत सभी कृषक देशों में उसका मृत्यु पूर्व का अन्तिम गीत बन जाता हैं"।[4]

मार्क्स एंव एंगेल्स ऐसे सर्वहारा क्रान्तिकारी थे, जिनके लिए विज्ञान स्वयम् उद्देश्य नहीं, बल्कि मजदूर वर्ग का बौद्धिक उपकरण था।

---

1. मार्क्सवाद और उपन्यासकार यशपाल : डॉ0 पारस नाथ मिश्र, पृष्ठ–41
2. लेनिनवाद मुक्ति तथा जातियों की प्रगति का ध्वज : सम्पादक – वी0आर0 कुल्लान्दा, सोवियत भूमि पुस्तिका, 1972, पृष्ठ–10
3. कार्लमार्क्सए लुई बोनापार्ट की 18 वीं ब्रूमेर (संकलित रचनाएँए खण्ड एक भाग दो)ए पृष्ठ–238
4. वही, पृष्ठ–240

उन्नीसवीं शदी का विचारक, दार्शनिक अन्तर्राष्ट्रीय के सर्वहारा के प्रणेता और वैज्ञानिक कम्यूनिज्म के संस्थापक कार्लमार्क्स का जन्म 5 मई, सन् 1818 ई0 प्रशिया के राइन प्रान्त के ट्रियर नगर के यहूदी परिवार में हुआ था। और इनकी मृत्यु 17 मार्च, 1883 ई0 लन्दन (हाइगेट कब्रिस्तान) में हुआ था। मार्क्स आधुनिक, एवं वैज्ञानिक तथा अधिकांश समाजवादी विचारधाराओं के सर्वमान्य जनक हैं। समग्र संसार के श्रमिक और क्रान्तिकारी आन्दोलन मार्क्स के प्रभावशाली विचारों से प्रभावित हुए हैं। इसलिए उन्हें अन्तराष्ट्रीय सर्वहारा के महान शिक्षक और नेता कहाँ जा सकता हैं। इस दृष्टि से मार्क्स संसार में न केवल महान अपितु युग प्रवर्तक विचारकों में से हैं।

पश्चिम यूरोपीय देशों में सामाजिक जीवन का अध्ययन कर मार्क्स ने सम्बोधन किया कि दुनिया के स्तर पर आर्थिक दृष्टि से मानव समाज दो ही वर्ग में बंटा है। पहला पूँजीपति दूसरा सर्वहारा। तात्विक आधार पर समाज के निरन्तर विकास की प्रकिया का आधार संघर्ष माना। अभी तक आर्विभूत समस्त समाज का इतिहास वर्ग–संघर्षों का इतिहास रहा हैं। आज पूरा समाज दो विशाल शत्रु शिविरों में एक दुसरे के खिलाफ खडें, दो विशाल वर्गो में पूँजीपति और सर्वहारा वर्गो में विभक्त होता जा रहा हैं। पूंजीपति वर्ग ने पारिवारिक सम्बन्धों के ऊपर से भावुकता का पर्दा उतार फेंका है और पारिवारिक सम्बन्ध को केवल द्रव्य के सम्बन्ध में बदल दिया हैं। "मार्क्स ने अपने विज़्न के फलीभूत होने को उम्मीद औद्योगिक रूप से विकसित उन देशों में की थी जहॉ पूंजीवाद ने जरूरी भौतिक आधार तैयार किया था लेकिन इतिहास ने मार्क्स की इस उम्मीद पर एक चाल चल दी। पहले विश्व युद्ध की समाप्ति के बाद यूरोपीय देशों में हुई क्रान्तियों में, मार्क्स ने जिसका अनुमान लगाया था। केवल रूसी क्रान्ति सफल हुई। पूँजीवाद द्वारा मुहैया किये गये आर्थिक, राजनीतिक और सांस्कृतिक उपलब्धियों के आधार पर समाजवाद का निर्माण एक अकेले पिछड़े हुए देश में करना पड़ा और वह भी सर्वाधिक शत्रुतापूर्ण पूँजीवाद के वैश्विक वर्चस्व के बीचो बीच। मार्क्सवादी शब्दावली का इस्तेमाल करें तो इस समाधान में उत्पादक शक्तियों का विकास और नए समाज के आधार के रूप में उत्पादन के समाजवादी सम्बन्धों का निर्माण साथ–साथ करना था। लेनिन ने इसे ऐसे संघर्ष के रूप देखा जिसमें 'पराजय'

एक विशिष्ट सम्भावना थी। उसने लिखा 'संघर्ष और केवल संघर्ष ही निर्धारित करेगा कि हम कितना आगें बढ़ पाते हैं।'[1]

'पूँजी' को मार्क्स ने मानव समाज के जीवन मूल्यों का नियामक माना। पूँजी की भूमिका में मार्क्स कहते हैं। "इस रचना का अंतिम उद्देश्य आधुनिक समाज (अर्थात पूँजीवादी) (बुर्जुआ समाज) की गति के आर्थिक नियम को खोलकर रख देना ही हैं।" इतिहास द्वारा निर्धारित समाज विशेष के उत्पादन सम्बन्धों का, उनके उद्भव, विकास तथा ह्रास का अनुसंधान यह हैं मार्क्स की आर्थिक शिक्षा का अंतर्य।[2] पूँजी के उत्पादन के नियमों के गहन अध्ययन कर उसने बताया कि पूँजी के बढ़ाव में पूँजी और मानवीय श्रम दोनो का योगदान होने के उपरान्त भी श्रम शक्ति की उपेक्षाकर पूँजीपति वर्ग व्यक्तिगत पूँजी निरन्तर बढ़ रहा है। ऐसे वर्ग को उसने शोषक वर्ग की संज्ञा दी। दुनिया भर में पूँजी उत्पादन की विद्या को एक मानकर उसने अपने अपने सिद्धांतो की प्रतिष्ठापना को जो निम्नवत हैं:–

(1)दुनियाभर के पूँजीपतियों का एक वर्ग हैं जिसे मार्क्स ने बूर्जुआ वर्ग की संज्ञा दी।

(2)श्रमिकों वर्ग जिसकी श्रमशक्ति का उपयोग पूँजीपतियों ने मनमाने ढ़ंग से की उस वर्ग को प्रोलिटेरियट कहा।

सैद्धान्तिक तौर पर विश्व के अन्य सामाजिक विकास पद्धतियों के चिन्तन (विशेष रूप से भारत) का बिना अध्ययन किये पूँजी के प्रति अपने दृष्टिकोण को सही मानकर संघर्ष के लिये सर्वहारा वर्ग को संगठित करने का आह्वाहन मार्क्स ने किया। पहली बार दुनिया के पैमाने पर मार्क्स ने शोषित जनता की सर्वहारा (पोरोतालियन) शब्द दिया। उसके शोषण की व्याख्या की कारणों का तलाश किया, और मुक्ति का क्रान्तिकारी दर्शन दिया है। वर्ग संघर्ष आर्थिक संघर्ष से मुक्ति पाने एवं पूँजीवादी व्यवस्था को भंग करने का एक सशक्त साधन हैं। आचार्य हजारी प्रसाद द्विवेदी का कथन हैं कि 'आज समाज केवल भावलोक का विद्रोह कर टाल सकता हैं, परलोक मानस में शुष्क धर्माचार व रूढ़ मान्यताओं के प्रति यह भाव लोक का विद्रोह किसी दिन वास्तविक के विद्रोह का रूप ले सकता हैं। यह वास्तविक लोक आधुनिक जीवन की

---

1. परख : एक वैकल्पिक प्रस्ताव पत्रिका – अक्टूबर 2001 से मार्च 2002, सुदर्शन आफसेट, इलाहाबाद, पृष्ठ–9

2. लेनिन : कार्लमार्क्स और उनकी शिक्षा – प्रगति प्रकाशन मास्को, प्रकाशन सन् 1989 ई0, पृष्ठ–21

विडम्बना मूलक व्यवस्था है और व्यापक रूप से उस समाज व्यवस्था से है जो जिसमें दलित सर्वहारा अभिशप्त जीवन जीने के लिए बाध्य हैं। इस प्रकार मार्क्स का सर्वहारा मूलतः समाज का शोषित दलित जनसमूह हैं जिसका मूल शत्रु पूँजीवादी व्यवस्था हैं। इसके विरूद्ध परिवर्तन का संघर्ष उसका मूल ध्येय हैं। ऐसी परिवर्तनकारी क्रान्ति की व्याख्या करते हुए भगत सिंह ने लिखा हैं – "क्रान्ति वर्गवाद, जातिवाद तथा राष्ट्र द्वारा राष्ट्र का, व्यक्ति द्वारा व्यक्ति के, किसी भी प्रकार के शोषण का अन्त कर देगा।"[1]

दुनिया के श्रमिकों की सामाजिक स्थिति में हर जगह भिन्नता थी। इसका बिना विचार किए पूँजीपतियों के खिलाफ संघर्ष करने की घोषणा एक असामयिक घोषणा सिद्ध हुए। औधोगिक महानगरों के सर्वहारा चेतनायुक्त होने के कारण पूँजीपतियों के खिलाफ संगठित होकर संघर्ष करने में पहले सफल सिद्ध होगे ऐसी मार्क्स की भविव्यवाणी थी। लेकिन इंग्लैण्ड और जर्मनी के मजदूर इसमें असफल रहें। जिस अनुपात में पूँजीपति वर्ग का, अर्थात पूँजी का विकास होता हैं। उसी अनुपात में सर्वहारा वर्ग का, आधुनिक मजदूरों के एक वर्ग का विकास होता है। जो तभी तक जिन्दा रह सकते है। जब तक उन्हं काम मिलता जाये और उन्हें काम तभी तक मिलता हैं जब उनका श्रम पूँजी में वृद्धि करता हैं। सर्वहारा वर्ग विकास की विभिन्न मंजिलों से गुजरता हैं। जन्म काल से ही पूँजीपति वर्ग से उसका संघर्ष शुरू हो जाता हैं। पूँजीपति वर्ग को अपने राजनीतिक उद्देश्यों की पूर्ति के लिए पूरे सर्वहारा वर्ग को गतिशील करना पड़ता है। और वह ऐसा करने में कुछ समय तक समर्थ भी होता है। इसलिए इस अवस्था में सर्वहारा वर्ग अपने शत्रुओं से नहीं,, बल्कि अपने शत्रुओं से, निरकुंश राजतंत्र अवशेषों, भूस्वामियों, गैर औधोगिक पूँजीपतियों, निम्न पूँजीपतियों से लड़ता है। इस प्रकार इतिहास को समस्त गतिविधि के सूत्र पूँजीपतियों के हाथों में केन्द्रित रहते है। इस प्रकार हासिल की गयी हर जीत पूँजीपति वर्ग की बढ़ती हुई आपसी होड़ और उससें पैदा होने वाले व्यापारिक संकटों के कारण मजदूरों की मजदूरी और भी अस्थिर हो जाती है।

सर्वहाराओं का अपना वर्गरूपी संगठन और फलतः एक राजनीतिक पार्टी के रूप में उनका संगठन उनकी आपसी होड़ के कारण बराबर गड़बड़ी में पड़ जाता है। लेकिन हर बार वह फिर उठ खड़ा होता है पहले से भी अधिक मजबूत दृढ़ और

---

1. दलित जन उभार : बहुजन चेतना मण्डप, प्रकाशक – बी0 एम0 एन0 प्रकाशन, लखनऊ, पृष्ठ–258

शक्तिशाली बनकर। पूँजीपति वर्ग अपने को लगातार लड़ाई में फंसा पाता है, पहले अभिजात वर्ग के साथ, फिर खुद पूंजीपति वर्ग के उन भागों के साथ, जिनके हित औद्योगिक प्रगति के प्रतिकूल हो जाते है और अन्ततः विदेशों के पूँजीपतियों के साथ तो सदा ही । अतः पूँजीपति वर्ग खुद ही सर्वहारा वर्ग को अपने राजनीतिक और सामान्य शिक्षण के तत्वों से सम्पन्न कर देता है, अर्थात् उनके हाथ में पूँजीपति वर्ग से लड़ने के लिए हथियार देता है । सर्वहारा वर्ग को ज्ञानोदीप्ति और प्रगति के नये तत्व प्रदान करते हैं ।

मार्क्स के साथ एंगेल्स ने भी सर्वहारा का चित्रण किया और दोनों एक दूसरे के पूरक है इसलिए अलग चिन्तन की कोई आवश्यकता नही'। बड़े–बड़े उद्योगों, मिल कारखानों, खानों, कल कारखानों, आदि मालिकों का वर्ग पूँजीपति वर्ग कहलाता है । यह वर्ग सम्पूर्ण देश की अर्थव्यवस्था की कुंजी को अपनी मुट्ठियों में बन्द रखता है और इसी कारण देश के आर्थिक क्रिया कलापों, उत्पादन, वितरण आदि पर इसका पूर्ण नियंत्रण होता है । कालमार्क्स ने इसी वर्ग को शोषण वर्ग श्रमिक वर्ग का खून चुसने एवं उसकी गॉढ़ी मेहनत की कमाई का अधिकांश भाग स्वयं "हडपने वाला वर्ग" कहा हैं। सामाजिक परिवर्तन लाने में इस वर्ग की जो भूमिका हैं। उसे भी अस्वीकार नहीं किया जा सकता। वर्तमान भारत में जो औद्योगीकरण की प्रक्रिया क्रियाशील है। वह वास्तव में इसी वर्ग की देन हैं। उद्योगों को शुरू करने तथा रोजगार की सम्भावना बढ़ाने में इसी वर्ग की भूमिका रही है।

पूँजीपति वर्ग अस्तित्व और प्रभुत्व की लाजिमी शर्त पूँजी का निर्माण और वृद्धि है। और पूँजी की शर्त हैं, उजरती श्रम पूर्णतया मजदूरों की आपसी होड़ पर निर्भर है। उद्योग की उन्नति जिसे पूँजीपति वर्ग अनिवार्यतः अग्रसर करता है। होड़ के कारण उत्पन्न मजदूरों के अलगाव की जगह पर उनका संसर्गजनिक क्रान्तिकारी एका कायम कर देती है। पूँजीपति वर्ग सर्वोपरि अपनी कब्र खोदने वालों को पैदा करता हैं। व्यक्तिगत पूँजी का अनियंत्रित संग्रह और पूँजीपतियों द्वारा उसका असीमित उपभोग देखकर मार्क्स ने सर्वहारा वर्ग के लिए अभिनव दिशा निश्चित की। उन्नीसवीं शती में राज्य की एक ऐसी शक्ति थी जो पूँजीपतियों के साथ लड़ने में सक्षम थी अन्यथा पूँजीपतियों के शक्तिशाली गिरोह के सामने सर्वहारा वर्ग का किसी भी प्रकार का संघर्ष

कर पाना असंम्भव था। इसलिए राज्यविहीन समाज की कल्पना कर चलने वाले मार्क्स ने सर्वहारा वर्ग को राज्यतंत्र पर कब्जा करने की प्रथम राजनीतिक आवश्यकता पर अधिक बल दिया।

राज्य को हाथ में लेकर सर्वहारा पूँजीपतियों के समूल नाश में सक्षम हो सकता है। इस प्रकार अर्थवादी चिंतक मार्क्स ने सर्वहारा की अधिनायक की राजनैतिक कल्पना कर सर्वहारा को आर्थिक वर्ग न बनाकर राजनैतिक वर्ग बना दिया। इस प्रकार विकास कम में सर्वहारा वर्ग अपना संगठन बनाकर राज्य सत्ता कैसे प्राप्त करे इसका चिन्तन ज्यादे करने लगा परिणाम सामने आया। कोई भी राजनैतिक वर्ग शोषण विहीन समाज की स्थापना करेगा यह अनुभव विश्व को बताता हैं कि असम्भव है। हाँलाकि इतना जरूर हुआ कि व्यक्तिगत पूँजीपतियों के खिलाफ राज्य शक्ति नियंत्रक हुईं । इसी का परिणाम हैं कि ब्रिटेन का मजदूर अपने लोकतांत्रिक स्वभाव के अनुसार संसदीय ढंग से राज्य पर नियंत्रण कर पूँजीपतियों के साथ समझौते पर चलने लगा और न सर्वहारा क्रान्ति ही पायी और न पूँजीपति समाज समाप्त हो पाया।

पूँजीपति और शोषक दोनों समझौते की स्थिति में हो गये उन्नीसवीं सदी के अंत में इसी तरह राज्य रचना के विरूद्ध संघर्ष की तैयारी करने वाला लेनिन रूस में पैदा हुआ। लेनिन के रूस में सर्वहारा का संघर्ष कहीं से पूँजीपतियों के विरूद्ध नहीं हुआ बल्कि एक राज्य व्यवस्था को संघर्ष के द्वारा बदलकर अपनी सत्ता स्थापित की मार्क्स का आर्थिक मानव राजनैतिक मानव हो गया मार्क्सवाद को आधार मानकर लेनिन ने संघर्ष किया। यह एक उसकी आवश्यकता थी। क्योंकि किसी भी संगठन की वैचारिक आवश्यकता को पूर्ण करना आवश्यक होता हैं। विचार का भी आकर्षण यदि चमत्कारिक न हो तो आकर्षण नहीं हो पाता यह कार्य रूस में मार्क्सवाद को करना पड़ा। रूस में सत्ता प्रतिष्ठान बदलने के बाद रूस सत्ता के खिलाफ संघर्ष करने वालों का आकर्षण केन्द्र बना और लेनिनवाद विचार के रूप में सबका प्रेरक तत्व बना। रूस में सर्वहारा के नाम स्थापित सत्ता के आर्दशानुरूप चीन और भारत में कुछ लोगों ने कार्य प्रारम्भ किया। सन् 1921 ई0 में चीन में माओंत्सेतुंग ने और भारत में मानवेन्द्रनाथ राय आदि ने चीन ऐसे अविकसित देश में माओं ने तत्कालीन राज्यव्यवस्था के विरूद्ध संघर्ष की कम आवश्यकता का अनुभव किया यदि तत्कालीन चीन की व्यवस्था पर

विचार किया जाय तो कोई ऐसी सत्ता नहीं थी जिसके नियंत्रण में सम्पूर्ण चीनी समाज है। युद्ध सरदारों और क्वेमिड0 ताड0 की संस्कारों द्वारा चीनी जनता का शासन होता था। उसी काल में जापान आक्रमण के रूप चीन में प्रविष्ट हुआ। जापान जैसे आक्रामक देश के विरूद्ध चीन को राष्ट्रवाद के आधार पर खड़ा किया जाय। यह आवश्यकता थी। और चीन मे गुरिल्ला युद्ध को आधार मानकर सारा संघर्ष शुरू हुआ। संघर्ष कि विकास क्रम में देश भक्ति के आधार पर चीनी सीमा को निश्चित कर उसने अपनी सर्वहारा शक्ति को खड़ा किया। शक्ति केन्द्र वाली संघर्ष की परिस्थितियॉ भिन्न थीं। अतः माओ ने बीहड़ जंगलो और पर्वतीय इलाको में, गांव के कबीला संस्कृति के लोगो को मिलाकर खड़ा किया। और उसने सर्वहारा की संज्ञा गांव के छोटे किसानों, निम्न पूँजीपतियों एवं पारम्परिक छोटे–मोटे व्यवसायों द्वारा जीविकार्जन करने वालों को दे डाली।

सन् 1949 ई0 में जापान की हार के बाद क्वोमिड़0 ताड़0 की सरकार को रूसी सेना की सहायता से गिराने में माओत्सेतुंग सफल हो गया। सन् 1949 ई0 में सर्वहारा अधिनायक शाही के नाम पर राज्य सत्ता स्थापित हो गयी । दुनिया के स्तर पर राजनैतिक मानव की भूख अर्थवादी चिंतन की आड़ में, शान्त हो गई।

भारत में सन् 1924 ई0 में मानवेन्द्र नाथ राय के सहयोग से कम्यूनिष्ट पार्टी की स्थापना हुई। सर्वहारा अधिनायकवाद की परिकल्पना जो रूस से प्राप्त की गयी थी उसको आधार बनाकर कार्य प्रारम्भ किया गया। उस समय ब्रिटिश सत्ता के खिलाफ भारत में स्वतंत्रता का संघर्ष चल रहा था। कोई देशी राजव्यवस्था ऐसी नही थी। जिसके विरूद्ध यह संघर्ष चले। सत्याग्रह और असहयोग के आधार पर गांधी जी का चल रहा संघर्ष स्वतंत्रता प्राप्ति में सफल हो गया और रूस की द्वितीय विश्व युद्ध की राष्ट्रीय आवश्यकता जो कि इग्लैण्ड की समर्थक थी, इस विषय पर रूस के अनुसार चलने के कारण कम्युनिष्ट पार्टी को काफी नुकसान हुआ और देश हित के विरूद्ध बिट्रेन से सहयोग की बात उनके काफी विपरीत गयी। भारत ऐसे सामाजिक विषमता वाले देश में सर्वहारा वर्ग में कौन–कौन से लोग सम्मिलित हो, यह विवादास्पद विषय बना हुआ है। भारत जैसे सामाजिक विषमता वाले देश में सर्वहारा वर्ग में कौन–कौन से लोग सम्मिलित हो, यह विवादास्पद विषय बना हुआ हैं। आज भी सामाजिक तौर पर

उपेक्षित और आर्थिक तौर पर पीड़ित लोगों का बहुत बड़ा वर्ग तो है। परन्तु साम्यवाद की सर्वहारा शब्दावली के अन्दर यह कितना अपने को समाहित मानता हैं। ऐसा आज तक कुछ दिखाई नहीं पड़ता।

लेनिन परिवारिक स्तर पर राज्य के अत्याचार का शिकार होने के कारण प्रतिशोध भाव से यह राज्य के उर्ध्वस्त करने के चिन्तन में लग गया उसने ऐसे सब लोगों का संगठन किया जो जारशाही के विरूद्ध थे। तत्कालीन राज्य व्यवस्था के विरूद्ध संघर्ष करने वाले पूरे समूह का अगुवा सर्वहारा होगा ऐसा रूस में उसने विचार कर राज्य के खिलाफ सभी असन्तुष्ट लोगों का गिरोह बनाया और सन् 1917 ई0 में सर्वहारा अधिनायकशाही को स्थापित करने में सफल हुआ।

प्राचीन काल में मेहनत कश लोग मालिको के दास थे दास आमतौर पर मालिक की पूर्ण सम्पति हुआ करते थे। दास उत्पादन के औजारों और अन्य साधनों के स्वामित्व से वंचित रहते थे। वे अपने श्रम संगठनकर्त्ता नहीं थे और केवल अपने मालिक के आदेश की पूर्ति किया करते थे मध्य युग में तथा औधोगिक क्रांति होने तक शहरों में दस्तकार भी थे जो निम्न पूँजीवादी उस्तादों के नौकर थे। मैनूफेक्चर के विकास के साथ मैनूफेक्चर मजदूरों का उद्भव होने लगा। सर्वहारा से मतलब आधुनिक उजरती मजदूरों से हैं, जिसके पास उत्पादन का अपना खुद का कोई साधन नहीं होता, इसलिये जो जीवित रहने के लिये अपनी श्रम–शक्ति को बेचने को विवश होते है।

आजादी के लड़ाई के समय सर्वहारा के अधिनायकवाद की व्यवस्था को लोगो के गले कोई उतार नही पाया। इसका दो कारण था। सर्वहारा के नाम पूरे देश में चाहे वह राजनैतिक क्षेत्र हो या लेखन का क्षेत्र हो नेतृत्व एक बनावटी सुविधावादी वर्ग के हाथ में रहा नागरीय गरीब लोगों पर नगरीय घूर्तता का असर रहा तो गॉव के गरीबों के गवांरूपन को सभी लोगों ने हिकारत की दूष्टि से देखा। आजादी के पूर्व मिलों में आन्दोलनात्मक कार्य करने वाला मजदूर नेता गांव से लौटकर ग्रामीण परिस्थितियों मे अपने को समरस करने में असमर्थ रहा।

सर्वहारा वर्ग स्वयम् अपनी पुरानी हस्तगत करण–प्रणाली का और इसके साथ–साथ पहले को सभी हस्तगतकरण–प्रणालियों का अन्त किये बिना समाज की हस्तगतकरण–प्रणालियों का अन्त किये बिना समाज की उत्पादक शक्तियों का स्वामी

नही बन सकता। सर्वहारा के पास जोड़नें और सुरक्षित रखने के लिए अपना कुछ भी नही है। उसका जीवन लक्ष्य निजी संपत्ति की सभी पुरानी गांरटियों और जमानतों को नष्ट कर देना हैं।............बुर्जुआ वर्ग के मुकाबले में आज जितने भी वर्ग खड़े हैं, उन सब में सर्वहारा ही वास्तव में क्रांतिकारी वर्ग हैं। दूसरे वर्ग आधुनिक उधोग के समक्ष ह्रासोन्मुख होकर वर्ग अंतत विलुप्त हो जाते हैं, सर्वहारा ही उसको मौलिक और विशिष्ट उपज हैं।[1]

सर्वहारा क्रांति का चिन्तन भारतीय चिन्तन के साथ उलझ गया है। विचारों के साम्राज्य में जीने वाला भारतीय समाज वर्ग संघर्ष एवें सर्वहारा की अधिकनायकशाही दोनों को स्वीकार करेगा, यह कठिन नहीं असम्भव भी प्रतीत होता। सुविधावादी नेतृत्व का शहरीकरण हो गया और सर्वहारा वर्ग भी वेतन भोगी बनकर रह गया और सर्वहारा क्रांति की इच्छा ही मर गयी क्योंकि क्रांति के पूर्व सम्भावित खतरे से जुझने का साहस उस नेतृत्व के पास न रहा न मजदूर के पास कोई योजना ही रही। स्वतंत्रता प्राप्ति के उपरान्त भी इर्द'–गिर्द कुछ ऐसा ही स्वरूप रहा, गॉव और शहर दो इकाई बने रहे। शहरी नेतृत्वकर्त्ता ऐसा चाहता ही नही की कोई दीर्घकालिन संघर्ष होगा। सामाजिक व्यवस्था एंव अर्थवादी जगत के भारतीय चिन्तकों की श्रृंखला में आने वाले मनीषियों को विचारधारा में पर्याप्त विभेद रहा हैं। पं0 दीन दयाल उपाध्याय जिन्होंने मार्क्सीय दृष्टिकोणों की पर्याप्त आलोचना की हैं। पूँजीवादी एवं साम्यवादी दोनों व्यवस्थाओं को विकृतिपूर्ण बताया है। सम्पूर्ण साम्यवादों चिन्तन के विरूद्ध वैचारिक संघर्ष की एक व्यापक शुरूआत उन्होनें अपने एकात्म मानववाद के विचार को प्रस्तुत किया हैं। उनकी सामाजिक विकास को प्रक्रिया के सम्बन्ध में मान्यता है। कि पारस्परिक सहयोग पर विकास सम्भव है। पूँजी का एकीकरण चाहे व्यक्ति के हाथ हो या राज्य के हाथ हो दोनों विशाल समाज के लिये अहितकर हैं। पूँजी के प्रति दृष्टिकोण यदि भारतीय हो जाय तो सारी समस्या का निदान सम्भव है, ऐसी उनकी मान्यता है। ऐसी ही स्थिति में भारतीय साम्यवादी चिन्तक चित्तन के धरातल पर जुझ रहा है। सामाजिक जीवन में उसको उपयुक्त वातावरण नहीं मिला और गांव एवं शहर के लोगों ने आर्थिक आधार पर कोई उचित स्वरूप संगठन के निर्माण में भी कोई विशेष सफलता नही प्राप्त की है।

---

1. सर्वहारा अधिनायकत्व : मार्क्स एंगेल्स, लेनिन – प्रगति प्रकाशन मास्को, 1985 पृष्ठ–13

एक दूसरे प्रश्न के प्रत्युत्तर में कि सर्वहारा का जन्म कैसे हुआ? कहा गया है कि सर्वहारा उस औधोगिक क्रांति के फलस्वरूप पैदा हुआ जो गत शताब्दी के उत्तरार्द्ध में इंग्लैण्ड में प्रकट हुई थी। और जिसकी तब से संसार के समस्त सभ्य देशों में पुनरावृत्ति होती रही हैं।[1]...............यांत्रिक उपकरणों की औद्योगिक क्रांति ने उद्योग की हर शाखा पर अपना आधिपत्य कर लिया, पूँजी पर हर वस्तु के मालिक बन गये। सभ्य देशों में श्रम की लगभग सभी शाखायें फैक्टरी प्रणाली के अन्तर्गत होती है, और लगभग तमाम शाखाओं में से दस्तकारी तथा मैनुफैक्टर को बड़े पैमाने के उघोगों ने बाहर धकेल दिया हैं। फलस्वरूप पहले के मध्य वर्ग खासतौर पर छोटे दर्जे के कारीगरों को बरबादी की ओर पहुँचा दिया गया हैं तथा दो नये वर्ग जो धीरे–तमाम अन्य वर्गों को अपने अन्दर समा रहे है,, अस्तित्व में आये है, अर्थात बड़े पूँजीपतियों का बुर्जुआ वर्ग, जो मशीनों और फैक्टरीयों आदि का स्वामी हैं तथा उन लोगों का वर्ग जिनके पास कुछ नहीं हैं और जीवन निर्वाह के आवश्यक साधनों को प्राप्त करने के लिए पूँजीपतियों को अपना श्रम बेचने के लिये वाध्य हैं, सर्वहारा वर्ग हैं।[2]

एक अन्य प्रश्न के प्रत्युत्तर में कि सर्वहारा क्या हमेशा से विद्यमान नहीं रहा हैं? लिखा गया हैं कि हां, नहीं रहे। गरीब लोंग तथा श्रमजीवी वर्ग हमेशा से रहे हैं तथा श्रमजीवी वर्ग अधिक गरीब रहे हैं। परन्तु ऐसे गरीब, ऐसे मजदूर अर्थात सर्वहारा, जो अभी अभी चर्चित अवस्थाओं के अन्दर रहे है, हमेशा से उसी अस्त्विमान नही रहें हैं जिस तरह होड़ हमेशा से मुक्त तथा बेलगाम नहीं रही है। 19वीं सदी के सर्वहारा की परिभाषा तथा सर्वहारा क्या है?, के प्रत्युत्तर में लिखा हैं कि सर्वहारा समाज का वह वर्ग हैं जो अपनी आजीविका के साधन पूर्णतया तथा केवल अपने श्रम की बिक्री से हासिल करता है, किसी पूँजी से हासिल किये गये मुनाफे से नही, जिसकी भलाई और दुख, जिसकी जिन्दगी और मौत, जिसका पूर्ण अस्तित्व श्रम की मांग पर, इस कारण अच्छे कारोबार के समय तथा बुरे कोरोबार के समय की अदला–बदली पर, बेलगाम होड़ से पैदा होने वाले उतार चढावों पर निर्भर करता हैं।[3] संक्षेप में सर्वहारा अथवा सर्वहारा वर्ग 19–या 20 वीं शताव्दी का श्रमजीवी वर्ग हैं।

---

1. फ्रेडरिक एंगेल्स, पृष्ठ–84
2. मार्क्स एंगेल्स : कम्युनिस्ट पार्टी का घोषणापत्र, पृष्ठ–85
3. वही, पृष्ठ–84

मार्क्स की परिभाषा का क्षेत्र और अधिक विस्तृत करते हुये माओत्सेतुंग अपने देश काल की सीमा में जो सर्वहारा की व्याख्या प्रस्तुत की वह निश्चय ही महत्वपूर्ण हैं। औद्योगिक सर्वहारा श्रमिकों के अतिरिक्त अर्द्ध सर्वहारा के रूप में प्रस्तुत माओत्सेतुंग की व्याख्या ने सर्वहारा समाज का एक बृहत रेखाचित्र प्रस्तुत किया है। चीन की विशाल जनसंख्या का अधिकांश भाग कृषि से जुड़ा हुआ था और दरिद्र किसानों की विशाल सेना दयनीय स्थिति झेल रही थी। ये न केवल औद्योगिक श्रमिकों के समकक्ष थे वरन् अनेक बातों में इनकी स्थिति सर्वहारा के ही समान थी। माओंत्सेतुंग के वर्गीकरण से जुड़ा अर्द्धसर्वहारा वर्ग भी अपनी महत्वपूर्ण भूमिका रखना हैं। 'माओं' ने कई सर्वहारा वर्ग की पाँच श्रेणियों की है।

(1) अर्द्ध भूमिधर किसानों की भारी बहुसंख्या:– इससे माओं का तात्पर्य यहाॅ उन जो अंशतः अपनी जमीन पर काम करते हैं और अशतः दूसरों से लगान पर ली हुई जमीन पर।[1]

(2) गरींब किसान

(3) छोटें दस्तकार

(4) दुकानदार कर्मचारी, इससे माओं का तात्पर्य है उन कर्मचारियों से जो तत्कालीन चीन में बहुसख्यक थे दुकान कर्मचारियों का एक निम्न तपका भी था जो सर्वहारा के समाज जीवन बिताता था।[2]

(5) फेरीवाले:– अर्द्वभूमिधर किसानों की भारी बहुसंख्या और गरीब किसान ये दोनों मिलकर देहात की आय जनता का बड़ा हिस्सा बन जाते हैं। किसान समस्या मूलतः इन्हीं की समस्या है। अर्द्वभूमिधर किसान, गरीब किसान और छोटे दस्तकार ये सब भूमिधर किसानों और मालिकों दस्तकारों से और[3] भी छोटे पैमाने के उत्पादन में लगे हुए हैं। यद्यपि अर्द्वभूमिधर किसानों की भारी बहुसंख्या और गरीब किसान दोनों ही अर्द्वसर्वहारा वर्ग में आता है, फिर भी अपनों आर्थिक स्थिति के हिसाब से उन्हे उच्च्, मध्यम और निम्न इन तीन श्रेणियों में बांटा जा सकता है। अर्द्वभूमिधर, अर्द्वभूमिधर किसानों की जिन्दगी भूमिधर किसानों की जिन्दगी से ज्यादा कठिन है, क्योंकि हर साल उन्हें अपनी जरूरत के लगभग आधे अनाज की कमी का सामाना करना पड़ता हैं। उन्हे

---

1. माओत्सेतुंग की संकलित रचनाएं, पृष्ठ–17
2. वही, पृष्ठ–17

दूसरों से लगान पर जमीन लेकर अपनी श्रमशक्ति का हिस्सा बेंचकर या छोटे–मोटे व्यापार में लगकर यह कमी पूरी करनी पड़ती हैं। बसन्त के अन्त और ग्रीष्म के शुरू में पौधों में हरा अनाज निकलनें के पहले और पुराने अनाज के चुक जाने के बाद, वे भारी व्याज पर कर्ज लेते हैं और ऊचें दाम देकर गल्ला खरीदते हैं.....[1]

............गरीब किसान देहात के आगामी किसान है, जिनका शोषण जमींदार करते है। अपनी आर्थिक स्थिति के हिसाब से उन्हे अन्य दो श्रेणियों में बांटा जा सकता हैं। गरीब किसानों की एक श्रेणी के पास अपेक्षाकृत रूप से काफी खेती औजार होते हैं और कुछ पूँजी भी होती है।...........जहां तक किसानों की दूसरी श्रेणी का सम्बन्ध है, उनके पास न तो खेती के पर्याप्त औजार होते हैं और न पूँजी होती हैं, उनके पास काफी खाद भी नही होती, जमीन से भी मामूली[2] दुकान कर्मचारियों को भी माओं ने थोड़ी पूँजीवाला हैं और गरीब किसानों के समकक्ष ही उन्हें भी क्रांति की जरूरत हैं। माओं ने कृषि और तत्सम्बन्धी जनों के विकट स्थिति का विश्लेषण अत्यन्त निकटता से किया था। और सर्वहारा वर्ग की सीमा में परिगणित किया। माओं ने आधुनिक औद्योगिक सर्वहारा वर्ग को बड़ा नही माना हैं किन्तु मुख्यतः रेलवें, खान, समुन्द्री परिवहन सूती, कपड़ा और जहाज निर्माण उद्योग में श्रमरत इनकी बड़ी तादात्म उन कारबारों में गुलामी करती हैं, जिनके मालिक विदेशी पूँजीपति है।

...................यद्यपि ये संख्या में कम हैं फिर भी उत्पादक शक्तियों के प्रतिनिधि है। ये केन्द्रित हैं। जनता का कोई दूसरा हिस्सा इतना केन्द्रित नहीं हैं। इसका कारण इसकी गिरी हुई आर्थिक स्थिति हैं। उनके उत्पादन के सभी साधन छिन चुके है, उनके पास अपने भुजबल के सिवाय और कुछ बाकी नही रह गया हैं[3] जिसे हम देहाती सर्वहारा वर्ग कहते है, उसका अर्थ है साल, महीने या दिन के हिसाब से काम पर लगाये जाने वाले खेत– मजदूर। इनके पास न जमीन है, न खेती न औजार हैं और न थोड़ी सी भी पूँजी हैं। वे जिन्दगी बसर करने के लिये केवल अपनी श्रम शक्ति को ही बेच सकते है। दूसरे मजदूरों की तुलना में वे सबसे ज्यादा घंटे काम करते है, सबसे

1. माओत्सेतुंग की संकलित रचनाएँ, पृष्ठ–10
2. वही, पृष्ठ–11
3. वही, पृष्ठ–13
4. वही, पृष्ठ–14

दस्तकारों की हैं। जिन्हे काम नही मिल पाता। वे सबसे अस्थिर जिन्दगी बिताते है........[1] माओं ने युद्ध सरदारों नौकरशाह, दलाल, पूँजीपति वर्ग, बड़े जमीदारों का वर्ग और उन पर निर्भर बुद्धिजीवियों को सर्वहारा वर्ग के लिए दुश्मन माना हैं तथा औद्योगिक सर्वहारा वर्ग को नेतृत्व सम्पन्न क्रांतिकारी वर्ग तथा अर्द्धसरकारी वर्ग और निम्न पूंजीपति वर्ग सर्वहारा के सवसे नजदीकी दोस्तों के रूप में स्वीकार किया हैं।

एम0 सिरोदोव ने सर्वहारा विश्लेषण क्रम में लिखा हैं कि दासमूलक समाज में श्रम के प्रति हिकारत का रूख व्याप्त हो गया। इसके फल स्वरूप रोम में एक ऐसा सामाजिक तबका पैदा हो गया, जिनके पास न तो गुलाम थे और न स्वयं श्रम करना चाहता था। ये साधनहीन पतित व्यक्ति परजीवीयों की तरह जीते थे। यहीं वह लम्पट सर्वहारा बने जिसकी रोटी और खेल तमाशे की मांग विख्यात है। (एम0 सिरोदोव, राजनीतिक विज्ञान ऐतिहासिक भौतिकवाद क्या है?) एम0 सिरोदोव को यह प्रस्तुत परिभाषा अपने तत्कालीन समाज में चाहे जिस रूप में भी व्याप्त हो आज के संदर्भो में यह पर्याप्त परिवर्तित हो चुकी हैं।

प्रख्यात विचारक लीवरेख्त ने भी श्रमजीवी वर्ग की व्यापक व्याख्या प्रस्तुत करते हुए लिखा हैं। कि इस प्रकार हमें श्रमजीवी वर्ग में मजदूरी करने वाले के अलावा छोटे–छोटे किसानों तथा छोटे– छोटे दुकानदारों को भी शामिल करना चाहिए........... कुछ लोग मानते हैं कि एक मात्र मजदूरी करने वाला सर्वहारा ही, सच्चा क्रांतिकारी वर्ग हैं, अकेले वही समाजवादी सेना बनाता है, हमें दूसरे वर्गो के जवीन के दूसरे क्षेत्रों के लोगों से सर्तक रहना चाहिये। सौभाग्य से इन ना समझी भरे विचारें का जर्मन सोशल डेमोक्रेसी पर कभी प्रभाव नहीं रहा।

प्रस्तुत विचारों के आधार पर कहा जा सकता हैं कि मार्क्स के सर्वहारा की व्याख्या देशकाल की सीमाओं के अनुसार पर्याप्त विस्तार पाती रही। न केवल औद्योगिक संस्थानों से जुड़ा श्रमिक ही सर्वहारा की संज्ञा पा सका और क्रांति का अग्रदूत बना वरन् वे सभी दलित, उपेक्षित अर्थहीन व्यक्तित्व इस सीमा में समाहित हो गये जो शदियों की घोर विद्रूपता से संघर्षशील होते रहे है।

---

1. माओत्सेतुंग की संकलित रचनाएँ, पृष्ठ–14

भारतीय विचारकों ने समाजवाद और समाजवाद के अग्रदूतों के रूप में जिस वर्ग की कल्पना की वह सर्वहारा से भिन्न नही है। ख्यातिलब्ध भारतीय राजनीतिक और विद्वान डॉ0 सम्पूर्णानन्द ने अपनी कृति समाजवाद में सर्वहारा की व्युत्पुत्ति, परिभाषा और आधुनिक स्थिति पर विचार व्यक्त करते हुए लिखा हैं कि प्राचीन काल में कारीगर स्वतंत्र थे बनाये माल का अधिकार रखते थे। आज को मशीनें करघों का विस्तृत रूप हैं। कारीगर ही इन कपड़ों के स्वामी बने और रूपया लगाने वाले को मूलधन व्याज चाहिये और वह अपने रूपयों की सन्तति को वृति निन्तर चाहने लगा। महायंत्रों ने रूपये वालों का पक्ष प्रबल कर दिया...............उन्हे स्वतंत्र कारीगर तो चाहिये नही, केवल मजदूर चाहिए अर्थात ऐसे लोग चाहिये जो पैसा लेकर श्रम करने को तैयार हो और अपनी मजदूरी मात्र से मतलब रखें[1].................यह कहा से आते है..............जिनके पास खेती बारी घर आदि कोई सम्पत्ति नहीं हैं। उनके पास अपने शरीर मात्र हैं। यह लोग अपने शरीर के स्वामी बने रहते हैं पर अपनी यहीं श्रमशक्ति को समय विशेष के लिए रूपये वाले के हवाले कर देते है। ऐसे लोगों के लिये कुछ दिनों से सर्वहारा प्रोलेटेरियन नाम चल पड़ा है। अकिंचन कहना भी बुरा न होगा।[2] वहीं सच्चा मजदूर हो सकता हैं जिसके पास कुछ न होते हुए भी एक वस्तु हैं। वह है उसकी श्रमशक्ति (लेबर पावर) श्रम करने की शक्ति। बस वह रूपयों वालों के हाथ इसी को बेचता हैं। यही उसका एक मात्र पण्य है।[3] डॉ0 सम्पूर्णानन्द ने देशकाल निरपेक्ष वस्तु स्थितियों को समीक्षित कर धनी और निर्धन की स्थिति भेद को स्पष्ट करते हुए हर युग में इसकी उपस्थिति की चर्चा की है। किन्तु इसके साथ ही वर्तमान जीवन की प्राणलेवा निर्मम आर्थिक शोषण की सत्यता को उद्‌धाटित करते हुए लिखा कि पहले भी धनी और निर्धन का भेद था, पर आज जैसा तीव्र न था..........ऐसे लोगों को गणना करना कठिन है जो प्राण पाल रहे हैं परन्तु न भरपेट अन्न पाते हैं न वस्त्र।[4] निश्चित ही सम्पूर्णानन्द जी को इस परिभाषा मे सर्वहारा को अन्तरंगी व्याख्या समाहित हैं। जीवन जीने की विवशता के साथ घोर आर्थिक विद्रूप की पीड़ा से जीवन के हर मोड़ पर मर्माहत होनेवाला वर्ग ही सर्वहारा हैं। आधुनिक सर्वहारा के सम्बन्ध में अन्यत्र लिखा हैं कि खेती बारी से दूर जीविकोपार्जन हेतु क्षुमित लोगों के पास सम्पति न थी। यह लोगों शुद्ध

---

1. समाजवाद : डॉ0 सम्पूर्णानन्द, पृष्ठ–139
2. वही, पृष्ठ–139–140
3. वही, पृष्ठ–140
4. वही, पृष्ठ–157

सर्वहारा थे। इनकी सन्तान ही आजकल कारखानों को चला रही हैं और बेकारों की संख्या बढ़ा रही है।[1]

सर्वहारा वस्तुतः वह श्रमिक वर्ग हैं जो शिवाय शरीर व मस्तिष्क के उनके पास उत्पादन का कोई दूसरा साधन नहीं हैं और कृषक वर्ग में केवल वे ही शोषित हैं। जो किसी भी अर्थ में भूमि के स्वामी न होकर जीविका के लिये दूसरों पर आश्रित है। अतः शोषित, श्रमिक और कृषक ही सर्वहारा हैं।[2] डॉ० सम्पूर्णानन्द की यह परिभाषा निश्चय ही माओत्सेतुङ्य के सर्वहारा वर्गीकरण को स्वीकार करने वाली है। भारतीय परिवेश में बहुधा सर्वहारा की श्रेणी में यही लोंग आते भी हैं।

प्रख्यात साहित्यकार शलम श्री रामसिंह ने सर्वहारा (PROLETARIAT) की व्यत्पुत्ति और आधुनिक संदर्भ में परिभाषित करते हुए लिखा हैं कि सर्वहारा मार्क्सवादी समाज संहिता की मानक शब्दावली का यह आधार शब्द मूलतः ग्रीक भाषा के शब्द 'प्रोल' से बना हैं। प्रोल का अर्थ होता है, सन्तान। इस प्रकार अपने व्यापक और विश्लेषित (किन्तु अपेक्षाकृत कम परिचित अथवा एक सीमा तक विस्मृत) रूप में प्रोलेटेरियन का मतलब हुआ समाज का वह मानव (वर्ग) जिसके पास सन्तान के अतिरिक्त कोई दूसरी सम्पत्ति न हो। अर्थात सन्तान ही धन हो, जिसका वह हुआ सर्वहारा किन्तु इसे सार्थक सन्दर्भ मे जोड़ते हुए और इसकी परिभाषा को परिस्थितिगत आग्रह से जोड़ने के क्रम में इसे जो प्रचलित तथा प्रथमतः स्वीकृत परिभाषित रूप रूसी क्रांति के सूत्रधारों के द्वारा प्रदान किया गया वह था, समाज का न्यूनतम वेतन भोगी श्रमिक वर्ग। सर्वहारा का यह अर्थ सन् 1917 ई0 में सम्पन्न होने वाली रूसी क्रांति के समय तक इसी सीमा के अन्तर्गत स्वीकृत और मान्य रहा किन्तु 1949 ई0 में माओंत्सेतुङ्ण्ग के नेतृत्व में परिपूर्ण होने वाली चीनी क्रांति की सफलता ने इस शब्द–(सर्वहारा) की सीमा को भूमिहीन ग्राम कृषकों से जोड़कर जो विस्तार प्रदान किया वह अपेक्षाकृत अधिक वैज्ञानिक और मानवीय होने के साथ ही साथ आधुनिकता से युक्त होने के कारण सहज रूप से ग्राह्य और विचारणीय बन गया और इसका मूल अर्थ न केवल स्थापित हुआ अपितु इस शब्द (सर्वहारा) की अर्थवत्ता अपनी व्यापकता के साथ ही साथ एक सर्व स्वीकृत सत्य के रूप में प्रतिपादित हो गई अर्थात सर्वहारा की परिभाषा प्रथमतः और अन्ततः एक और केवल यही बन पायी कि सर्वहारा वह है[3]

----

1. समाजवाद : डॉ0 सम्पूर्णानन्द, पृष्ठ–172
2. वही, पृष्ठ–340
3. शलभ श्री रामसिंह, एस0 4/ 24, बेलूर हाउसिंग इस्टेट सापुई पारा (बाली), हाबड़ा (पं0 बंगाल)

जिसके पास संतान के अतिरिक्त कोई दूसरी चल अचल सम्पति न हो। इस दृष्टि से विवेकानन्द का शूद्र और मोहनदास करमचन्द गांधी का 'हरिजन' भारतीय सर्वहारा के अतिरिक्त और कुछ भी नहीं है।[1]

शलमजी ने सर्वहारा की ग्रीक व्युत्पत्ति के सन्दर्भ क्रम को आधुनिक परिप्रेक्ष्य में संदर्भित कर जो व्याख्या प्रस्तुत की हैं, उसमें एक बात निर्विवाद रूप से सामने आयी कि सर्वहारा कहे जाने वर्ग के पास चल अचल सम्पति के रूप में मात्र साढ़े तीन हाथ का यह शरीर ही है। जिसके द्वारा इस संसार के हर संघर्ष से उसे जुझना पड़ता हैं। अपना कहनें के लिये और क्या हैं ही उसके पास सन्तान के रूप में इस समाज को वह मात्र हाड़ मांस से निर्मित एक शरीर हो तो दे पाता है?

आधुनिक भारतीय विचारकों ने भी सर्वहारा की परिभाषित आधुनिक संदर्भो में प्रस्तुत की हैं। रजनी पामदत्त के "आज का भारत" में नेहरू का यह कथन उद्धृत हैं कि कृषीय प्रणाली अब ध्वस्त हो चुकी है और समाज का नया संगठन अवश्यम्भावी हैं। सन् 1933 ई0 में जवाहर लाल नेहरू का कथन।[2] निश्चय ही यह नया संगठन आने वाले औद्योगिक सभ्यता के परिप्रेक्ष्य मे संकेतित किया गया है। लेखक ने इसी लक्ष्य से भारतीय सर्वहारा के विषय में अपना अभिमत प्रस्तुत किया है कि जमीन से बेदखल किसान एक ऐसी स्थिति में पहुँच गये हैं जो कृषिदास प्रथा के काफी करीब हैं या वे दिन व दिन बढ़ती हुई भूमिहीन सर्वहारा की एक सेना की शक्ल अख्तियार कर रहे हैं। यही वह प्रकिया हैं जो आने वाले तूफ़ान की सूचना दे रही है।[3]

दूसरे शब्दों में हम कह सकतें है कि शोषित जनता ही सर्वहारा की श्रेणी में आता हैं। आर्थिक, सामजिक स्तर पर शोषित उपेक्षित वर्ग सर्वहारा हैं, जो कि मार्क्स का सर्वहारा गांधी का हरिजन तथा अम्बेड़कर का दलित चिंतन और अवधारणा हैं। सर्वहारा का शब्द मार्क्स के शब्दों में "जिनको खोने के लिए जंजीरे है, पाने के लिये सारी दुनिया से है" "मूलतः मार्क्स का चिन्तन आर्थिक से शोषित दलितों के पक्ष का रहा हैं। मार्क्स का सर्वहारा पूँजीवादी समाज का दलित है जो आर्थिक रूप से वंचित हो उनके अनुसार सर्वहारा वर्ग का जन्म पूँजीवादी वर्ग से हुआ है। पूँजीपति और सर्वहारा समाज के बुनियादी वर्ग है। पूँजीवाद मजदूरों को उनके श्रम के फल से वंचित करता हैं। समाज में मजदूर की यह वंचित स्थिति पूँजीपतियों से लड़ने को विवश करती है।[4]

---

1. शलभ श्री राम सिंह, एस0 4/ 21, बेलूर हाउसिंग इस्टेट, सापुई पारा (बाली), हाबड़ा (पं0बंगाल)
2. आज का भारत : रजनी पामदत्त, अनुवादक – आनन्द स्वरूप वर्मा, दि मैकमिलन कम्पनी आफ इण्डिया लिमिटेड, पृष्ठ सं0 – 239
3. समस्त विश्व में सहयोगी कम्पनियां : पृष्ठ–239
4. दलित जन उभार : प्रकाशन – बी0 एम0 एन0 प्रकाशन, लखनऊ, पृष्ठ – 257–258

सर्वहारा का ध्येय और कर्त्तव्य पूँजीवादी समाज को समाप्त करना और वर्गविहीन समाज का निर्माण करना है।[1]

आधुनिक पूँजीवादी समाज ने जो सामन्ती समाज के ध्वंस से पैदा हुआ है, वर्ग विरोधी को खत्म नहीं किया। उसने केवल पुराने के स्थान पर नये वर्ग, उत्पीड़न की पुरानी अवस्थाओं के स्थान पर नयी अवस्थाएं और संघर्ष के पुराने रूपों की जगह नये रूप खड़े कर दिये हैं। किन्तु दूसरे युगों की तुलना में हमारे युग की पूंजीवादी युग की विशेषता यह हैं कि इसने वर्ग विरोधों को सरल बना दिया। आज पूरा समाज दो विशाल शत्रु शिविरों में एक दुसरे के खिलाफ खड़े दो विशाल वर्गो में पूँजीपति और सर्वहारा वर्गों में अधिकाधिक विभक्त होता जा रहा हैं। मार्क्स कहते है "सर्वहारा उस दंडादेश को निष्पादित करता है जो निजी सम्पत्ति सर्वहारा को उत्पन्न करके अपने को सुनाती है, जिस प्रकार वह उस देश जिस प्रकार वह उस दंडादेश को भी निष्पादित करता है, जो उतरती श्रम औरों के लिए धन और अपने लिए निर्धनता उत्पन्न करके अपने को सुनाता है ।"[2]

'सर्वहारा ' को परिभाषित करते हुये मार्क्स ने कहा है कि – मजदूर अथवा सर्वहारा वर्ग उन श्रमिकों का वर्ग है जो जबतक जी सकते है जब तक की उन्हें काम मिलता रहे । यह काम उन्हें तब तक ही मिलता है, जब उनके श्रम से पूंजी बढ़ी हो । श्रमिक लोग अपने को अलग अलग बेचनें के लिये लाचार है, किसी भी अन्य व्यापारिक माल की तरह एक बिकाऊ माल है। मार्क्स ने सर्वहारा और पूंजीपति को उत्पत्ति के लिये समाज का ऐतिहासिक तथा द्वन्द्वात्मक भौतिकवादी विश्लेषित करते हुये सिद्धान्तीकरण किया है।

प्रख्यात कथाकार जैनेन्द्र कुमार ने अपनी कथाकृति "अनामस्वामी" में एक स्थान पर सर्वहारा का विश्लेषण करते हुये 'शंकर उपाध्याय' के शब्दों को अंकित किया है कि किसान सर्वहारा के श्रेणी में नही आता। इसलिये वह क्रान्ति का साधन नहीं हो सकता वह छोटी–मोटी ममताओं में रहता है । जमीन उसे अपनी चाहिए। पर अपना क्या है ? कोई जमीन अपने पेट से बॉधकर लाया है ? बांधकर ले जायेगा ? सबका यहीं के यहीं

---

1. दलित जन उभार : प्रकाशन बी0एम0एन0 प्रकाशन, लखनऊ, पृष्ठ–257–258
2. कम्यूनिष्ठ घोषणा पत्र : मार्क्स एंगेल्स, प्रगति प्रकाशन – मास्को हिन्दी अनुवाद सन् 1984, अनुवादक : नरेशवेदी, पृष्ठ–25

रहने को है इस लिये जमीन के चप्पे–चप्पे से लड़ने वाला किसान अन्त में प्रतिगामी सिद्ध होता है ।[1]

लेखक ने आधुनिक भारतीय सर्वहारा का उत्स औपनिवेशिक प्रणाली से उद्धृत करते हुए लिखा है कि – भारत की जनता को उसके जमीन से बेदखल कर दिया गया हालांकि इस प्रक्रिया की ओर भी जटिल कानूनी रूपों की भूल–भूलैया द्वारा अशंतः ढका गया जो आज डेढ़ सौ वर्षों के बाद एक दूसरे में उलझी प्रणालियों, काश्तकारियों, परिवारियों और अधिकारों का अभेद्य जंगल बन गयी है ।[2] यह प्रक्रिया जब और आगे बढ़ी तो किसानों का एक बढ़ता हुआ हिस्सा पिछले सौ वर्षों में ओर खासतौर से पिछले पचास वर्षों में भूमिहीन मजदूर बन गया अर्थात खेतिहर सर्वहारा का एक नया वर्ग तैयार हो गया जो आज खेती पर निर्भर एक तिहाई आबादी से बढ़कर आधी आबादी तक पहुंच गया है ।[3]

सर्वहारा की इन परिभाषाओं पर दृष्टिपात करने पर एक बात स्पष्ट हो जाती है कि समाज के किसी भी क्षेत्र में श्रमरत वह त्यक्तित्व जो आवश्यकीय जीवन साधनों की अप्राप्ति के कारण शोषित होता है उसे सर्वहारा की श्रेणी में परिगणित किया जा सकता है । मार्क्स, एंगेल्स लेनिन और माओत्सेतुंग की परिभाषाओं की सीमायें आधुनिक युग में और अधिक विस्तृत होती जा रही है। भारत जैसे विशाल कृषि प्रधान देश का भूमि से जुड़ा एक बहुत बड़ा वर्ग यदि सर्वहारा की श्रेणी में खड़ा है तो अनिश्चित और अल्प आय वाले निम्न मध्यवर्गीय समाज का भी सर्वहारा स्वरूप बहुत स्पष्टता के साथ उभरा है।

स्वातंत्र्योत्तर हिन्दी कथा साहित्य में भारतीय सर्वहारा जीवन का पारदर्शी प्रत्यांकन इस सत्य को उद्घाटित करता है कि इस देश की अधिकांश जनसंख्या निर्धनता की सीमा रेखा से जीवन यापन कर रही है और अर्थहीन स्थिति से प्रति क्रान्ति उसका जीवन दुर्वह हो उठा है। प्रबुद्ध साहित्यकारों ने मार्क्स द्वारा प्रयुक्त 'सर्वहारा' शब्द के साथ उन सभी लोगों को सम्बद्ध कर लिया है जो शोषण व्यवस्था का अभिशाप भोगते हुए विषम जीवन व्यतीत कर रहे हैं।

---

1. अनाम स्वामी : जैनेन्द्र कुमार, सन् 1974 पृष्ठ–272
2. समस्त विश्व में सहयोगी कम्पनियां : पृष्ठ–242
3. आज का भारत : रजनी पामदत्त, पृष्ठ–245

(ख) मार्क्सवाद का सारभूत तत्व :

मार्क्सवाद मूलतः एक साहित्यिक आंदोलन नहीं था लेकिन सभी देशों के साहित्य पर उसका दूरगामी प्रभाव पड़ा है। साहित्य की भावधारा और शिल्प विधान को भी उसने परिवर्तित कर दिया। मानव–समाज के विकास को वैज्ञानिक दृष्टिकोंण से देखने का प्रयत्न मार्क्स ने किया था । दार्शनिकों ने केवल जगत की व्याख्या की है पर मुख्य बात है उसको बदलने की, यही उनका दृष्टिकोण था। मार्क्स का सिद्धान्त सामान्यतया द्वन्द्वात्मक भौतिकवाद नाम से अभिहित होता है। द्वन्द्वात्मकता से उनका मतलब विचारों के संघर्ष और गतिशीलता से था। भौतिकवाद शब्द का प्रयोग भी सोद्देश्य था । वे पदार्थ की सर्वोपरिता को स्वीकारते है । कोई पराभौतिक शक्ति के अनुसार इस संसार की गतिविधियां संचालित होती है, यह मत उनके लिए मंजूर नहीं था । मार्क्स ने जगत के मूल में भौतिक तत्व को स्वीकार कर आत्मा, मन, मस्तिष्क तथा विचारों को भौतिक पदार्थों से उत्पन्न स्वीकार किया। वे हेगेल के भाववादी दर्शन के विरोध में उभरे फायर बाख के भौतिकवाद से काफी प्रभावित थे और अपने इतिहास दर्शन को इतिहास की भौतिकवादी अवधारणा कहते थे । उन्होनें मानव समाज के इतिहास का आर्थिक और भौतिक दृष्टिकोंण से विवेचन किया है।[1]

वस्तुतः मार्क्स ने पहली बार भौतिक वाद का इस्तेमाल संगत ढंग से मनुष्य के समाज और इतिहास की व्याख्या करने के लिए किया। उन्होंने कहा कि जीवन के उत्पादन की क्रिया के दौरान कायम सामाजिक सम्बन्ध समाज की वह बुनियाद है, जिस पर राज्य, धर्म, विचारधारा और कला की इमारत खड़ी होती है । और यह कि मनुष्य के सामाजिक अस्तित्व का निर्धारण उसकी चेतना नही करती, बल्कि चेतना का निर्धारण उसका सामाजिक अस्तित्व करता है । उनके दर्शन की एक प्रमुख प्रस्तावना ही थी भौतिकवादी या वैज्ञानिक ढंग से यथार्थ के आत्मपरक व्यावहारिक पहलू की खोज । इसके अलावा उन्होंने स्पष्ट रूप से कहा कि विचार जब जनता द्वारा ग्रहण कर लिये जाते है,[2] तब भौतिक शक्ति बन जाते है । यानी, वे वस्तुगत यथार्थ के परिवर्तन में सक्रिय भूमिका निभाते है । द्वन्द्वात्मक भौतिकवाद के दूसरे प्रतिपादक और मार्क्स के सहयोगी एंगेल्स ने आज तक का सारा दर्शन भौतिकवाद और भाववाद के दो विरोधी खेमों में बँटा रहा है । प्रकृति से मनुष्य का सीधा सम्बन्ध शारीरिक श्रम के जरिए ही

---

1. स्वातंत्र्योत्तर हिन्दी उपन्यास : आर० सुरेन्द्रन, पृष्ठ–25
2. परख (एक वैकल्पिक प्रस्ताव) : पत्रिकाए अक्टूबर 2001 से मार्च 2002,पृष्ठ–51

होता है । लेकिन जब मानसिक श्रम शारीरिक श्रम से अलग हो जाता है तब वह अपने को प्रकृति से भी स्वतंत्र महसूस करने लगता है । चूँकि मनुष्य द्वारा उत्पादन और सृजन के हर कर्म में चेतना और उद्देश्य की अग्रगामी भूमिका होती है, इसलिए चेतना शारीरिक श्रम के जरिए निर्मित होने का भ्रम भी पाल लेती है । कुल्हाड़ी की रूप–रेखा (माडॅल) अगर लुहार के दिमाग में मौजूद हो, अगर वह कुल्हाड़ी का विचार बना सका हो, तभी वह कुल्हाड़ी को वस्तुगत रूप दे सकता है, वास्तविक कुल्हाड़ी का निर्माण कर सकता है । लेकिन कुल्हाड़ी चेतना के भीतर से पैदा नहीं होती लोहा चेतना से पहले ही प्रकृति में मौजूद होता है । जिसकी तलाश करके और उपयोगिता समझकर मनुष्य उसे अपने उपयोग की भिन्न वस्तुओं में डाल सकता है । वर्ग और श्रम विभाजन समाज में चेतना का भ्रम वस्तुओं के निर्माण में अपनी एक अहम भूमिका को स्थापित करने में नही है, बल्कि वस्तुओं को अपने भीतर से रचने में और इस तरह समूचे वस्तु जगत को अपनी कृति समझने में है । भौतिक पदार्थ का सिर्फ रुप बदला जा सकता है, उसका उत्पादन नही किया जा सकता।

पदार्थ और चेतना के द्वन्द्वात्मक सम्बन्ध को उभारने और भाववाद को भ्रान्त चेतना के रूप में खारिज करने वाले मार्क्स और एंगेल्स के इस ऐतिहासिक विश्लेषण की हो अनिवार्य परिणति थी उनके द्वारा दर्शन या विश्व दृष्टिकोण के वर्ग चरित्र का उद्घाटन। उन्होंने अपने दर्शन को औद्योगिक मजदूर वर्ग या सर्वहारा का विश्व–दृष्टिकोण कहा,जो आज तक का सबसे संगठित, प्रौद्योगिकी के सबसे उन्नत औजारों से लैस और सबसे क्रान्तिकारी वर्ग है। उनके अनुसार सर्वहारा वर्ग समाजवाद और साम्यवाद की स्थापना में आम जनता को नेतृत्व देकर श्रम विभाजन के बुनियादी रूप और व्यक्तिगत सम्पत्ति का अन्त कर देगा और इस तरह उसके आधार पर उसमें भाववाद और धर्म जैसे भ्रान्त–चेतना के विभिन्न रूपों का अस्तित्व भी मिट जायेगा।[1]

सर्वहारा वर्ग की तानाशाही का मार्क्स ने उल्लेख किया था। इसका यह अर्थ नहीं है कि वे तानाशाही के समर्थक थे। शोषण से मुक्त एक समाज की सम्भावनाएं कम हो जायेंगी। अपनी आवश्यकताओं की पूर्ति के लिए स्वयम् उत्पादन में लग जायेंगे। अनुत्पादन वर्ग का शोषण असंभव है। वर्ग चेतना युक्त श्रमिक वर्ग सामाजिक परिवर्तन के लिए क्रांति मचाता है। तदन्तर होने वाले युग दो भागों में विभाजित रहेंगे,

---

1. परख (एक वैकल्पिक प्रस्ताव) : पत्रिका, अक्टूबर 2001 से मार्च 2002,पृष्ठ–51

poultry manure and neem cake were most effective in reducing disease incidence due to *Meloidogyne incognita* and increasing the yield of greengram. Toor and Bahl (1999) concluded that application of poultry manure maintained P in available form to soybean.

2.3.4 Beneficial effects of crop residue in crop production

Application of N through FYM or fertilizer or combination of crop residue gave nearly equal yields (Anon., 1980). Chittapur (1998) stated that agricultural and industrial wastes, which consist of all biodegradable forms of refuse including crop residues and dung of the livestock, need to be recycled and put to productive use.

2.3.5 Organic matter in relation to crop production

Blondel (1971) reported that organic manuring influenced mineralization of N already present in soil. Besides, organic amendment enhanced N fixation in soybean, which also helped to increase the total N content in the crops. Shinde and Ghosh (1971) explained the increase on the basis of a large production of CO_2, which had a solubilizing effect on soil phosphate, and production of organic ions resulting in retarded fixation of phosphate by iron and aluminium.

Singh and Srivastava (1971) stated that addition of organic amendments increased N availability by mineralization and reducing losses of N. Warren and Garry (1985) reported that crop yields were higher with the application of organic manures in mixed farming system. Soil pH, organic matter, P, K, and total N were significantly higher with organic treatment than with other treatments.

Patel *et al.* (1992) stated that there is a need to develop a system using organic manures and inorganic fertilizers in a complimentary way. Addition of compost prepared with calotropis and castor cake increased the availability of N and P. According to Itnal (1998) less use or in some cases no use of mineral fertilizers and increasing reliance on plant, soil or/and animal residues and adoption of biofertilizers to partially substitute commercial fertilizers should be the strategy for future land management, particularly, for dryland areas. He also opined that organic manures have been generally valued as source of the primary nutrients, but they are a potential source of micronutrients too.

Poleshi (1998) stated that one of the schools of thought on organic matter interaction with the availability of micronutrients is that there is an increase in the availability of these nutrients with increase in organic matter content. Prabhakar *et al.*

(1998) stated that combined application of inorganics and organics improved soil physical condition and eventually helped sugarcane crop.

Radder in 1998 suggested that whenever manure is available, combining manure application with a crop rotation involving legumes could be an effective crop management practice. Shukla (1998) observed that integrating animal and green manures improved the productivity of the rice-rice system and maintained soil health. The greatest benefit of organic manures was generally the residual effect on the rabi crop.

2.4 Biofertilizer

Research done by Maheshwari (1974) shows that the biofertilizer component is a viable alternative for partial replacement of inorganic fertilizers. Dubey in 1992 found that use of biofertilizers as a source of N and P could minimize dependence on chemical fertilizers. The biofertilizer, which are generally seed inoculated, colonize in the rhizosphere (Kulkarni, 1998). They utilize the root exudates, grow and metabolize in the rhizosphere.

2.4.1 Crop characteristics as influenced by rhizobial inoculation

Richardson *et al.*, 1957 stated that stimulatory effect of N with *Rhizobium* inoculation might be ascribed to more rapid growth and hence the production of more infection sites resulting improved nodulation. *Rhizobium* inoculation to legumes increases the yield and has other beneficial effects also (Rao, 1980). Daterao and Lakhdive (1992) observed that *Rhizobium* inoculation to the preceding greengram crop decreased the requirement of N by 4 kg ha^{-1} compared with non-inoculation and addition of Molybdenum decreased further the N requirement of succeeding wheat.

Subbian and Palaniappan (1992) opined that integrated use of N along with biofertilizer resulted in higher returns compared with application of fertilizer N alone. Application of 75 % of recommended N along with biofertilizer was the most economic N-management practice to get higher returns per rupee spent on different cropping systems. Legumes, grown either as sole or as intercrops, gave higher grain yields under the reduced (75 %) N level along with *Rhizobium* inoculation. The yield increase under this practice ranged from 6.3 % in soybean to 30.9 % in cowpea.

Mathan *et al.* (1994) reported that combined application of urea (25 kg ha^{-1}) + 0.75 t FYM ha^{-1} enriched with 50 kg P_2O_5 ha^{-1} as rock phosphate + basal application of 6.25 t FYM ha^{-1} + seed inoculation with *Rhizobium* + spraying di ammonium phosphate

at 2.5 kg ha^{-1} at 55 and 70 DAS gave the highest pigeonpea seed yield and seed protein content. Patil (1998) studied the response of different pulse crops to Rhizobial inoculation. They found that *Rhizobium*-legume symbiosis can meet 80 per cent of the N requirement, if initial requirement could be met from the chemical fertilizer.

2.4.2 Influence of *Azospirillum* inoculation on crop and soil

Shah and Joshi (1986) observed that wheat responded well to *Azospirillum* application coupled with higher (100%) N level. High response to N application and in addition, beneficial effects of *Azospirillum* inoculation such as better root growth, secretion of growth-promoting substances (gibberellin, cytokinin and auxin) and availability of N fixed by micro-organisms might have exerted favourable impact on the yield. *Azospirillum* + NPK treatment produced higher values of certain yield parameters and available N (Ram *et al.*, 1992).

Cotton, onion, coriander, sunflower, cabbage and cauliflower, performed better under reduced N levels with *Azospirillum* (Subbian and Palaniappan, 1992). They observed 3.4-12.9 % higher yields than with application of 100 % fertilizer N alone. Patil *et al.* (1992) observed that Azospirillum helped not only in increasing the green-forage production but also had more favourable effect on dry-matter and crude protein yields of fodder maize.

Patel *et al.* (1993) concluded that 10 kg N ha^{-1} with seed treatment of 0.003 *Azospirillum* may give grain yield on par with application of 20 kg N ha^{-1}. The treatment 0.005 *Azospirillum* + 10 kg N ha^{-1} was observed to be the most economical among all the treatments for finger millet. Investigating the effect of fertilizer and Azospirillum on grain yield of rainfed wheat, Sawarkar and Goydani (1996) suggested that the recommended dose of fertilizers may be reduced when Azospirillum is used.

In multilocational trials conducted by Alagawadi (1998), pearlmillet and other crops have revealed better inoculation response with no or low levels of N fertilizers. The positive response of crop plants to *Azospirillum* inoculation could also be ascribed to hormonal effects and enhanced nutrient uptake. Kunnal (1998) suggested that application of vermicompost (2.5 t ha^{-1}) could substitute 25% recommended dose of fertilizer. Application of *Azospirillum* @ 10 kg ha^{-1} along with vermicompost (2.5 t ha^{-1}) could substitute 50% of inorganic fertilizer.

2.4.3 Contribution of Phosphate Solubilizing Bacteria in enhancing agronomic characteristics of crop

The legumes also left more available P in the soil for succeeding crop. According to Rao (1982) this could be assigned to the fact that the roots of legumes secrete certain acidic substances, which dissolve insoluble P converting into easily assimilable form. This may be also because the roots attract microorganisms due to their root secretions and in turn produce phosphate-solubilizing acids and convert insoluble form into soluble form. Phosphorus solubilization by microorganisms is found to be most important. The solubilization of P by these organisms is attributed to excretion of organic acids like citric, glutamic, succinic, lactic, oxalic, glyoxilic acids (Subbarao, 1983).

Tomar *et al.* (1993) observed that the application of phosphate-solubilizing bacteria significantly increased the seed yield of blackgram over the control from 9.5 in the 1st year to 22.5 % in the 2nd year. Tomar *et al.* in 1994 stated that phosphate-solubilizing bacteria increase the efficiency of applied phosphate and crop response, when the soybean seed were treated with the inoculants. Seed inoculation with phosphate-solubilizing bacteria + 50 kg P_2O_5 ha^{-1} was found superior to the other treatment for yield and yield components in opium poppy. According to Ramamoorthy and Arokiaraj (1997) the yield components of greengram at 25 kg P_2O_5 ha^{-1} as MRP + seed inoculation increased with phosphobacteria.

2.4.4 Crop characteristics as influenced by application of VAM

Santhi and Kothandaraman (1995) found that inoculation with VAM increased the dry matter yield of greengram. The yield increase with the soil inoculation was highest where 25 kg P_2O_5 was applied. Soil inoculation also increased the uptake of N, P, Ca and Mg.

2.5 Integrated Nutrient Management (INM)

Integration of plant nutrient sources *viz.,* N through FYM or fertilizer or combination of crop residue gave nearly equal yields (Anon, 1980). Roy and Braun (1984) opined that systems approach of plant nutrition would be advantageous for optimizing the use efficiency of different sources of plant nutrients. Researches conducted by Biswas *et al.* (1985) reveal differential magnitudes of complimentary effect through conjunctive use of *Rhizobium* along with mineral fertilizers to crops. Dravid and Goswami in 1988

observed similar and positive effects of integration of chemical fertilizers with organic manures.

In sub-humid red and laterite soils Sarkar *et al.* (1989) reported that organic manures applied in conjunction with low NPK dose resulted in higher grain yield in major cropping systems. Integrated use of 20 kg N + 20 kg P_2O_5 + FYM gave highest seed yield of blackgram as observed by Latha and Subramanian (1991). INM using FYM and inorganic fertilizer produced significant and higher agronomically important plant characteristics (Gangwar and Singh, 1992). Integrated use of N along with biofertilizer resulted in higher return in cowpea compared with application of fertilizer N alone, Subbian and Palaniappan (1992).

Application of 75 % of recommended N along with biofertilizer was the most economic N-management practice to get higher returns per rupee spent on different cropping systems. Legumes, grown either as sole or as intercrops, gave higher grain yields under the reduced (75 %) N level along with *Rhizobium* inoculation. Nambiar and Abrol (1992) have also reported similar results. Ram *et al.* in 1992 reported highest mean seed yield of sunflower with FYM with NPK.

Azospirillum + NPK treatment produced higher values of certain yield parameters and available N. Reddy *et al.* (1992) found that application of farmyard manure @ 5 tonnes ha^{-1} along with 20 kg N and 20 kg P ha^{-1} recorded highest dry matter during reproductive stage and gave higher grain yield than the other fertility levels. Studies have indicated that integration of chemical fertilizers with organic sources of nutrients generally proved superior to the use of each component separately (Singh and Yadav, 1992).

Raju *et al.* (1993) reported overall improvement in growth and yield attributes due to the synergistic effects of combined use of NPK with organic manures was reflected in the increased grain yield in rice. Gill *et al.* in 1994 observed that farmyard manure @ 6 tonnes ha^{-1} + 50% recommended inorganic fertilizers was significantly better than 100% recommended inorganic fertilizer in producing grain yield of wheat.

Mathan *et al.* (1994) reported that combined application of urea (25 kg ha^{-1}) + 0.75 t FYM ha^{-1} enriched with 50 kg P_2O_5 ha^{-1} as rock phosphate + basal application of 6.25 t FYM ha^{-1} + seed inoculation with *Rhizobium* + spraying di ammonium phosphate at 2.5 kg ha^{-1} at 55 and 70 DAS gave the highest pigeonpea seed yield and seed protein content. Krishnamoorthy (1995) found that net returns were higher with vermicompost + *Azospirillum* + recommended dose of fertilizer in sorghum.

Madhavi *et al.* (1995) observed that increasing levels of NPK fertilizers, poultry manure and their interaction significantly increased the dry matter production and yield attributes in winter maize. Grain yield was comparable in treatments 100% RDF + 4.5 t poultry manure ha^{-1}, 100 % RDF with 3.0 t poultry manure ha^{-1} and 50% RDF + 4.5 t poultry manure ha^{-1}. Nagaraju *et al.* in 1995 reported that seed yield increased with rate of organic manure and P application was higher with MRP + inoculation than with SSP. Grain yield and nodule dry weight were highest with a combination of 10 t organic manure, 100% of recommeded MRP rate + inoculation.

Chinnusamy and Rangasamy (1997) observed that yields of individual crops were higher when recycled composted poultry or pigeon manure was applied at 5 t ha^{-1} to rice. Replenishment of soil fertility was possible by the application of composted or recycled organic manure and recommended NPK fertilizers to each crop in the cropping system.

Dubey *et al.* in 1997 observed comparable grain yield in wheat due to application of 100% NPK, 75% NPK + 6 t FYM or 50% NPK + 12 t FYM ha^{-1} to *kharif* crops and 75-100% NPK to wheat. Orgainc fertilizers alone or in combination with inorganic fertilizers increase the level of organic carbon as well as the total NPK content of the soil (Sarkar and Singh, 1997).

Average rice yield was higher with RDF followed by 50% NPK + FYM. Patil *et al.* observed in 1997 that combination of VC @ 4 t ha^{-1} + 50% RDF recorded maximum yield proving that this treatment could substitute 50% RDF and produce 52.46% more yield over RDF. The compatibility of organic and inorganic forms of nutrient carriers for a balanced nutrient management is inevitable for increased growth. This has been emphasized amply by other researchers (Pawar, 1997).

Bobde *et al.* (1998) concluded that reduction in dose of N and P to 50% of the recommended dose and when supplemented with 7.5 tonnes FYM ha^{-1} gave significantly more grain yield and monetary returns than the RDF. Dayal and Agarwal in 1998 opined that substitution of inorganic fertilizers with recycled organic wastes is imperative for higher productivity of the soil. Organic manures have been recorded to enhance the efficiency and reduce the requirement of chemical fertilizers. They also reported that the interaction effect between organic sources and fertilizer levels was significant.

Dubey (1998) noted that biofertilizers and their combination with NPK was able to improve the growth attributes compared with the control. PSB inoculation alone or with VAM as dual inoculation was found more beneficial. Thus integrated use of two or

three types of biofertilizers was found to be superior to single biofertilizer. Integrated use of biofertilizers with NPK (half dose) is beneficial than biofertilizers alone or combined inoculation.

George *et al.* (1998) reported that *Azospirillum* inoculation integrated with 50% combined N fertilizer application was found sufficient to give comparable fodder yield of guinea grass as with 100 % NPK treatment. Hegde in 1998 observed that in wheat, the treatments receiving 50% N through green-manure or farmyard manure in preceding pearl millet and 100% NPK to wheat recorded significantly more yield than that which received 100% NPK through fertilizers during both the seasons. The total productivity of the system showed that farmyard manure or green manure could easily substitute 50% N needs of pearl millet in pearl millet – wheat cropping system.

Integration of fertilizers and organic sources improves the organic carbon status of soil, which helps in long-term sustainability. Patil *et al.* (1998) reported that comparable yields and net income from tomato crop were realised with the recommended rate of inorganic fertilizer + vermicompost at 2 t ha^{-1} and 50 % recommended + vermicompost at 4 t ha^{-1}. Sharma *et al.* (1999) stated that uptake of NPK was less when fertilizers were applied through inorganic source. The reduction is likely to be due to greater loss of N through leaching, volatilization, or fixation in soil and/or due to less mineralization and release of soil nutrients.

2.6 Physico chemical status of soil

Prasad *et al.* (1971) observed reduction in K losses from soil by addition of organic amendments. Shinde and Ghosh (1971) explained the increase in P availability during organic matter decomposition on the basis of a large production of CO_2, which had a solubilizing effect on soil phosphate and production of organic ions resulting in retarded fixation of phosphate by iron and aluminium. Sadanandan and Mahapatra (1973) also observed that pH of the soil decreased after 2 years under all cropping sequences, as a result of using of inorganic fertilizers.

Agboola *et al.* (1975) also observed reduction in K losses by addition of organic amendment. Effect of upland multiple cropping systems and fertilizer constraints on some chemical properties of soil was studied by Rao and Sharma (1976). The increase in organic carbon content was mainly due to addition of considerable amount of leaf litter and other crop residues in soil. The external application of P to crops in general and legumes in particular in different seasons enriched the soil with available P (Ahlawat *et al.*, 1981).

FYM improves the soil properties and finally crop yields (Bhatia and Shukla, 1982). Sharma *et al.*, 1985 opined that inclusion of legumes in rotation improves soil structure, enriches soil nitrogen and results in higher productivity of succeeding crops.

Warren and Garry (1985) reported that soil pH, organic matter, P, K, and total N were significantly higher with organic treatment than with other treatments. Increase in organic carbon content with integrated nutrient supply was mainly due to addition of organic matter as reported by Patnaik *et al.* in 1989. Geethakumari and Shivashankar (1991) observed that organic amendment comprising of ragi husk and FYM mixed in 1:1 ratio by weight promoted organic carbon content and available P status of the soil. Availability of K was also favourably influenced.

Ram *et al.* in 1992 reported that *Azospirillum* + NPK treatment produced highest values of available N and soil organic carbon when 10 t FYM ha^{-1} was applied. Bhogal, *et al.* (1993) noticed positive significant correlation between available Zn, Cu, Fe, Mn and B with organic carbon. Increase in organic matter decreased the deficiency of micronutrients since these elements are in complex with organic compounds, which prevent from certain harmful reactions that may render them to unavailable form.

Mathan *et al.* (1994) reported that the available nutrient status of the soil after harvesting of pigeon pea increased with the combined application of urea, FYM, P_2O_5 and *Rhizobium* inoculation. Newaj and Yadav, 1994 opined that though substantial amount of crop residues is returned to the soil, inclusion of legumes in the system is one of the important ways to ameliorate organic carbon, total nitrogen, soil aggregation, bulk density and available phosphorus in the soil. Singh *et al.* in 1994 stated the beneficial properties of farmyard manure as supplying additional plant nutrients, improvement of soil physical condition and biological process in soil.

Nayak *et al.* (1995) noted that combination of FYM and NPK gave high N, P and K contents in residual soil after fingermillet crop. According to Ramamurthy and Shivashankar (1996) during *rabi* season, maximum uptake of NPK nutrients was recorded. This could be due to the residual effect of nutrients available through organic source and fixation of atmospheric N by soybean in *kharif*. Organic manure helped in enrichment of the soil with nutrients and fixation of atmospheric N by preceding crop (i.e., soybean) significantly.

According to Tuivavalagi and Silva (1996) post-harvest soil analyses revealed that the addition of chicken manure significantly increased the concentration of NO_3^--N, Zn and Ca. Organic fertilizers alone or in combination with inorganic fertilizers increase the level of organic carbon as well as the total NPK content of the soil (Sarkar and

Singh, 1997). Rao and Sitaramayya (1997) studied the effect of various organic manures including FYM and poultry manure and observed that the available N content of soil was increased at 45 and 60 days after treatment due to transformation of N and later decreased at harvest due to plant utilization.

Prabhakar *et al.* (1998) stated that cropping systems have altered the dynamics of soil fertility. Combined application of inorganics and organics improved the physical condition of the soil. The neutralizing effect on pH, increase in organic carbon and available nutrient status of P_2O_5 and K_2O also showed improvement due to the integration.

The combined application of chemical fertilizers with organic manures has favoured for improving the physical, chemical and biological conditions of soil (Itnal, 1998). This also helps in raising mineralization efficiency and nutrient recovery from organic resource. This may be attributed to the fact that the organic manure has, among other properties, the capacity to improve the condition of the soil and enhancing the root development. Hiremath and Kalappanavar (1998) have observed this phenomenon.

Maheswarappa *et al.* (1999) observed that there was increase in the OC and pH of the soil under different treatments except NPK alone and control. OC content was increased to 0.380-0.381% under FYM and 0.391% under vermicompost treated plots compared to NPK alone (0.198 %) from the initial value of 0.21%.

2.7 Component crops in an INM system

2.7.1 Soybean

2.7.1.1 Effect of INM on soybean cropping

According to Singh *et al.*,1979, in soybean showed increase in seed yield with the application of rice straw or poultry manure + 2.5 ppm Zn. Application of the fertilizers singly or in combination increased LAI and photosynthetic efficiency of soybean (Bisht and Chandel, 1991). The highest photosynthetic rate and N physiological efficiency were obtianed with application of 80 kg P_2O_5 + 10 t FYM.

Subbian and Palaniappan (1992) opined that with the integrated nutrient-supply approach combining organic and biological sources along with chemical fertilizers would be more remunerative for getting higher returns with considerable fertilizer economy. Integrated use of N along with biofertilizer resulted in higher returns compared with application of fertilizer N alone. The yield increase under this practice ranged from 6.3 % in soybean.

Sharma and Bhardwaj (1993) found that application of Udaipur Rock Phosphate (URP) + 10 t poultry manure gave the highest seed yield in soybean. Shroff in 1994 opined that phosphorus solubilising microorganisms help in minimising the phosphorus fixation as it mineralizes native phosphorus. Combined application of fertilizers, *Rhizobium* and phosphorus solubilizing microorganisms has enhanced soybean yield significantly.

Bobde *et al.* (1998) reported that 50% reduction in recommended dose of fertilizer to soybean along with 7.5 tonnes of FYM ha^{-1} gave significantly (12%) more grain yield as well as 11.2% more monetary returns than the absolute control and RDF, folowed by 5.0 tonnes FYM ha^{-1} treatment. Navale and Gaikwad (1998) observed that seed yield of soybean increased up to 40:80 kg N: P_2O_5 (3 t ha^{-1}) and was higher with FYM than *Leucaena* cutting (3.23 vs 2.93 t).

Moharram *et al.* (1999) found that Brady*Rhizobium* + compost significantly increased nodule numbers, plant dry weight, N yield and N fixation compared with uninoculated plants. Inoculation increased the microbial biomass of C and N. Soil biomass increased with increasing compost rates, while soil organic matter, total C and available N contents were increased over the control, particularly with inoculation.

The grain and straw yields of rice obtained from the combined application of 50 % NPK + 50% poultry manure or FYM were statistically comparable to the NPK dose alone (Dubey and Verma, 1999). Highest increase in yield was obtained from combined use of 50% NPK + 50% poultry manure. Integration of 50% NPK + 50% poultry manure or FYM was advantageous in sustaining the crop and soil productivity and obtaining higher net returns.

2.7.1.2 Dry matter accumulation in soybean as affected by INM practices

Nimje and Seth (1988) found that FYM @ 15 t ha^{-1} recorded significantly higher dry matter yield at flowering and harvest stage. Prasad, *et al.* (1993) noted that application of 60 kg P_2O_5 ha^{-1} influenced significantly the amount of dry matter/ plant compared with other levels.

Hsieh and Hsu (1995) observed that vegetable soybean performed best with pig manure compost with microorganism mixture containing nitrogen-fixers, PSB, VAM etc. Jain and Tiwari in 1995 reported that N, P and K contents in soybean straw were highest with 5 t FYM + 5 t pressmud. Moharram *et al.* (1999) found that Brady*Rhizobium* + compost significantly increased plant dry weight compared with uninoculated plants.

2.7.1.3 Root nodulation in soybean as influenced by INM

Prasad (1977) also observed increase in nodulation due to phosphorus application in soybean. Prasad *et al.* (1981) found that the response of applied P in improving the seed size. This may be attributed to its significant role in regulating the photosynthesis, root enlargement and microbial activities. Singh and Bajpai (1990) observed that nodulation of soybean was significantly affected by phosphorus.

Prasad and Hajare (1992) inferred that the translocation of photosynthates to the site of nodule formation, particularly at flowering stage, might have also improved the nodulation. Prasad *et al.* (1993) noted that application of 60 kg P_2O_5 ha^{-1} influenced significantly the number of nodules/plant compared with other levels.

Dubey in 1998 opined that biofertilizers mainly *BradyRhizobium japonicum*, phosphate solubilizing bacteria (PSB) and VAM are commonly used for soybean production and they have an enormous potential to fix atmospheric N_2 and also have capacity to solubilize and mobilise P and micronutrients present in non-available form in the soil.

Vara *et al.* in 1998 observed that the number of nodules decreased with increasing level of N application. This might be because at higher levels of N, plant receives its N from N applied to the soil. Bacteria do not fix atmospheric N, as they become inactive in the presence of sufficient soil N, which is evident from the fewer number of nodules recorded at higher levels of N. Moharram *et al.* (1999) found that *Bradyrhizobium* + compost significantly increased nodule numbers and N fixation compared with uninoculated plants.

2.7.1.4 Nutrient status of soil and response of soybean in the cropping system

Blondel (1971) reported that organic manuring influenced mineralization of N already present in soil. Besides, organic amendment enhanced N fixation in soybean, which also helped to increase the total N content in the crops. According to Singh *et al.*,1979, in soybean the highest seed yield was obtained with the application of rice straw or poultry manure + 2.5 ppm Zn. Mascarenhas *et al.* (1980) studied the effects of poultry manure on soybean. The seed yield was comparable with other treatments.

Prasad *et al.* (1981) found that the response of applied P in improving the seed size may be attributed to its significant role in regulating the photosynthesis, root enlargement and microbial activities. Ahmad and Jha (1982) reported increase in yield

of soybean [*G. max* (L.) Merr.] due to inoculation with *Bacillus megaterium* and *B. circulants*. Nema *et al.* (1985) has also reported beneficial effects of phosphorus application on grain yield of soybean. Jayapaul and Ganesaraja (1990) observed that all phosphorus levels of 40, 80 and 120 kg ha^{-1} recorded significantly higher plant height, pods/plant, seeds/pod, hundred grain weight, grain yield and protein content.

Singh and Bajpai (1990) observed that the yield attributes of soybean, viz., number of pods/plant, grains/plant, and weight of hundred grains were also increased significantly due to phosphorus fertilization. Dahtonde and Shava (1992) concluded that *Rhizobium* inoculation significantly increased the pods/plant and test weight and consequently the grain yield significantly over no inoculation. Subbian and Palaniappan (1992) stated that integrated use of N along with biofertilizer resulted in higher returns compared with application of fertilizer N alone.

Prasad, *et al.* (1993) noted that application of 60 kg P_2O_5 ha^{-1} influenced significantly the number of nodules/plant, dry matter/ plant, pods/plant, 100-seed weight and grain yield/plant compared with other levels. Although soybean registered the highest compound growth in area expansion, the productivity is very low (920 kg ha^{-1}) compared to that of the world average of 2,002 kg ha^{-1} (FAO, 1995).

Hsieh and Hsu (1995) observed that vegetable soybean performed best with pig manure compost with microorganism mixture containing nitrogen-fixers, PSB, VAM etc. Jain *et al.* (1995) noted that seed yield was highest with 5 t pressmud + 5 t FYM ha^{-1}. Application of pressmud and FYM increased seed protein and oil contents. Increased grain yield of soybean with 5.0 t FYM ha^{-1} was also reported. Pradhan *et al.* (1995) observed that the protein and oil content was found significantly superior when 20 kg P_2O_5 ha^{-1} was applied to soybean.

Bachav and Sabale 1996 observed that the seed yield, seed protein and oil contents were the highest with 50% each of urea and FYM. Bisht and Chandel in 1996 observed cultivar PK-327, soybean registered highest seed yield and protein content with application of NPK and Zn, whereas seed oil content was highest with P + FYM. Ansari *et al.* (1998) observed yield increase in soybean with increasing rates of fertilizer and highest yield was recorded with poultry manure.

Navale and Gaikwad (1998) observed that seed yield of soybean increased with up to 40:80 kg N: P_2O_5 (3 t ha^{-1}) and was higher with FYM than *Leucaena* cutting (3.23 vs 2.93 t). Vara *et al.* in 1998 observed that *Rhizobium* inoculation increased the seed and straw yield. This may be due to the significant and progressive effect of *Rhizobium* inoculation on yield attributes, which ultimately resulted in higher seed yield. Protein

and oil yields were appreciably increased with increasing levels of P and seed inoculation with *Rhizobium* culture.

According to Halvankar *et al.* (1999) a fertilzer dose of 20 kg N + 80 kg P_2O_5 + 40 kg K_2O ha^{-1} should be applied to soybean crop for obtaining higher seed yields. Goswami (1999) reported that pods per plant, seeds per pod and test weight were increased significantly upto 60 kg P_2O_5 ha^{-1}. This resulted in higher net return, seed protein and seed oil. Mishra *et al.* (1999) explained the improvement in soybean yield charecteristics as due to increased rhizobial population in the rhizosphere due to liming.

Muir and Hedge (1999) found out that KCl decreased yield in 3 out of 4 years, but poultry manure and P did not affect yields. The grain and straw yields obtained from the combined application of 50 % NPK + 50% poultry manure or FYM were statistically comparable to the NPK dose alone (Dubey and Verma, 1999). Highest increase in yield was obtained from combined use of 50% NPK + 50% poultry manure. Integration of 50% NPK + 50% poultry manure or FYM was advantageous in sustaining the crop and soil productivity and obtaining higher net returns. The overall improvement in growth and yield attributes due to the synergistic effects of combined use of NPK with organic manures was reflected in the increased grain yield.

2.7.1.5 Influence of INM on the physicochemical soil status after soybean crop

Organic manuring influenced mineralization of N already present in soil, (Blondel, 1971). Besides, organic amendment enhanced N fixation in soybean, which also helped to increase the total N content in the crops. Shivashankar *et al.* (1976) reported that organic manuring influenced mineralization of N already present in soil. Besides, organic amendment enhanced N fixation in soybean.

Geethakumari and Shivashankar (1991) observed that organic amendment comprising of ragi husk and FYM mixed in 1:1 ratio by weight promoted organic carbon content and available P status of the soil. Availability of K was also favourably influenced. Organic amendment being a rich source of carbon enhanced the content of carbon. The additional increase in carbon content was due to the presence of soybean, which added more organic matter by shedding of leaves and sloughing of its root system. Organic amendment played an effective role in the mobilization of phosphate sources.

Gopalkrishnan and Palaniappan in 1992 observed that after harvest of soybean, FYM applied plots had medium available N and high available P as compared to no

FYM treatment. Application of FYM did not show any significant effect on the soil available K. Sharma in 1992 observed that the application of FYM improved the physico-chemical properties of the soil. Ramamurthy and Shivashankar (1996) also reported higher yields in soybean with 10 t FYM ha^{-1} and reduced dose of P.

Dubey and Verma (1999) observed that the different treatement combinations of NPK and FYM did not significantly influence the pH and EC values of the soil. The soil organic carbon increased by 51% under FYM application as compared to the initial value of 0.45%. Sharma *et al.* (1999) stated that the uptake of NPK was less when fertilizers were applied through inorganic source. The reduction is likely to be due to greater loss of N through leaching, volatilization, or fixation in soil and/or due to less mineralization and release of soil nutrients.

2.7.2 Mustard

2.7.2.1 Dry matter of mustard as influenced by INM

Prasad *et al.* in 1991 observed that the highest dry matter was obtained with 100 kg P_2O_5 and 10 t poultry manure ha^{-1}. Tomar *et al.* (1992) stated that owing to hardy nature mustard [*B. juncea* (L.) Czernj. & Cosson] is raised without adequate irrigation and fertilization. The dry matter was increased significantly with application of N, P and K upto 80, 40 and 40 kg ha^{-1} due to increase in growth and yield attributes. Patel *et al.* in 1998 found that FYM application increased the N uptake and dry matter content significantly. Thakur and Chand (1998) suggested that in rapeseed mustard dry-matter accumulation increased significantly up to 120 kg N ha^{-1} at harvest. None of the crop-growth stages showed significant difference due to N levels.

2.7.2.2 Yield of mustard as influenced by INM

According to Sharma and Puri (1987) application of 50 kg P_2O_5 gave highest net profit. Inoculation with *Rhizobium* in the preceding blackgram crop increased the yield. Under rainfed conditions low levels of P were more effective. Saran and Giri (1990) reported increase in yield and yield attributes of mustard due to P application. Dubey and Khan (1993) observed that the crop response to application of N upto 90 kg ha^{-1} was significant. An appreciable improvement in oil yield was noted due to supply of N upto 90 kg ha^{-1} and S upto 40 kg ha^{-1} during both the years. Increase in oil yield was mainly owing to increase in seed yield.

Punia *et al.* (1993) observed that the application of 40 kg P_2O_5 ha^{-1} was found superior to 20 kg P_2O_5 ha^{-1} for siliquae/plant and single plant seed yield of mustard.

Significantly higher seed yield was obtained with 40 kg P_2O_5 ha^{-1} which was, however, statistically on a par with 60 kg P_2O_5 ha^{-1}. Application of 40 kg P_2O_5 gave the highest yield over 20 and 60 kg P_2O_5 ha^{-1}. Nitrogen and phosphorus help increase in yield and quality of Indian mustard (Antil *et al.*, 1996). Patel *et al.* in 1996 opined that seed yield increased by 10 t ha^{-1} (2.72 t ha^{-1}) which was highest with 75 kg N (2.87 t ha^{-1}) and was highest with fertilizer containing S (2.80 vs 2.56 t).

Thakur and Chand (1998) suggested that in rapeseed mustard, fertilizers contribute 37-73% towards increase in the yield through the adoption of full package of practices and hence there is need to optimize fertilzer use. In maize (*Zea mays*) – mustard (*B. campestris*) cropping sequence, Sahoo and Panda (1999) reported statistically comparable seed yields of mustard crop grown on residual fertility of kharif maize at FYM alone, FYM with 50% RDF and FYM with 100% RDF.

2.7.2.3 Oil content of mustard as influenced by INM

Khan and Agarwal (1985) reported that increasing levels of irrigation and fertility resulted in a significant decrease in oil content of seed and higher oil content was recorded without irrigation and fertilization. Tomar *et al.* (1992) stated that with application of N, P and K upto 80, 40 and 40 kg ha^{-1} oil yield was significantly higher, while oil content in seed was higher under no fertilization

Dubey and Khan (1993) observed that the crop response to application of N upto 90 kg ha^{-1} was significant. An appreciable improvement in oil yield was noted due to supply of N upto 90 kg ha^{-1} and S upto 40 kg ha^{-1} during both the years. Increase in oil yield was mainly owing to increase in seed yield. Sardana and Sidhu (1994) stated that organic manures and N rates of up to 150 kg ha^{-1} applied in equal splits increased the seed protein content of the crops. There was a negative correlation between seed protein content and oil content with increasing N rate. P applications increased oil and protein contents. Green manure + 30 kg P_2O_5 gave the highest oil yield and FYM + P was less effective. Tomar *et al.* in 1997 observed that the seed oil concentration was decreased by N and P but increased by applied S.

2.7.3 Cowpea

2.7.3.1 Dry matter of cowpea as influenced by INM

Murthy *et al.* (1990) observed that drymatter of cowpea was not significantly influenced due to fertilizer levels. Highest total drymatter production was recorded at 25:25:25 NPK fertility level at harvest. According to Meenakumari and Nair (1992) soil

inoculated with VAM, *Rhizobium* and given rock phosphate (30 kg P_2O_5 ha^{-1}) produced a maximum dry weight at 45 days than other combinations.

Patil *et al.* (1992) observed that the biofertilizer *Azospirillum* helped not only in increasing the green-forage production but also had more favourable effect on dry-matter and crude protein yields of fodder maize. Jena *et al.* (1995) observed that in cowpea, cv. EC-4216 dry matter yield was higher with one cut. The dry matter yield was highest with 20 kg N + 40 kg P_2O_5 (3.37 t ha^{-1}).

2.7.3.2 Nodulation of cowpea as influenced by INM

Nagaraju *et al.* in (1995) reported that nodule dry weight was highest with a combination of 10 t organic manure, 100% of recommeded MRP rate + inoculation. Lopes *et al.* in 1996 observed that inoculation + refuse compost at 16% v/v and Na NO_3 at 25 mg N kg^{-1} significantly increased nodulation and dry matter yield of cowpea.

2.7.3.3 Yield of cowpea as influenced by INM

Murthy *et al.* (1990) observed that yield attributes of cowpea were not significantly influenced due to fertilizer levels. Subbian and Palaniappan (1992) stated that application of 75 % of recommended N along with biofertilizer was the most economic N-management practice to get higher returns/rupee spent on different cropping systems. Legumes, grown either as sole or as intercrops, gave higher grain yields under the reduced (75 %) N level along with *Rhizobium* inoculation. The yield increase under this practice ranged from 6.3 % in soybean to 30.9 % in cowpea. Jena *et al.* (1995) observed that in cowpea, cv. EC-4216 the green forage yield was higher with two cuts than one.

2.7.3.4 Protein content of cowpea as influenced by INM

Gangwar and Singh (1992) observed that significantly higher crude protein yield was recorded with 100 % recommended inorganic fertilizier, followed by 6 tonnes of farmyard manure ha^{-1} + 50 % inorganic fertilizer.

2.7.4 Blackgram

2.7.4.1 Effect of INM on blackgram cropping

Khandkar and Shinde (1991) reported the positive influence of phosphate to blackgram. Latha and Subramanian (1991) observed that application of 20 kg N + 20 kg P_2O_5 + FYM gave highest seed yield of blackgram. Mahanta and Borah (1998)

observed that poultry manure and neem cake were effective in increasing the yield of blackgram.

2.7.4.2 Nodulation of blackgram as influenced by INM

Singh *et al.*, (1993) reported that inoculation caused significantly higher number of effective nodules per plant.

2.7.4.3 Yield of blackgram as influenced by INM

Shrivastava *et al.* (1980) also reported that the yield attributes significantly improved, and grain yield increased progressively with an increase in level of P. According to Sharma and Puri (1987) application of 50 kg P_2O_5 gave highest net profit. Inoculation with *Rhizobium* increased the yield. Under rainfed conditions low levels of P were more effective. Latha and Subramanian (1991) observed that application of 20 kg N + 20 kg P_2O_5 + FYM gave highest seed yield of blackgram.

Dwivedi *et al.* in 1993 reported that application of N, P and Mo along with *Rhizobium* inoculation increased the grain yields of blackgram. Inoculation increased the yield than no inoculation (Singh *et al.*, 1993). Similar effects of inoculation on yield attributes like number of pods/plant, length of pods, number of seeds/pod and 1,000-seed weight were also observed.

Mishra (1993) observed that the grain yield increased progressively with an increase in level of P and maximum response was at 60 kg P ha^{-1}. P @ 60 kg ha^{-1} gave 43, 29 and 13% higher grain yield than control, 20 and 40 kg P ha^{-1} respectively. Yield attributes were also significantly improved owing to application of 60 kg P ha^{-1} compared with the unfertilized and the plots receiving fertilizer @ 20 and 40 kg P ha^{-1}. Singh *et al.* (1993) opined that inoculation increased seed yields and uptake of N and P in blackgram. The applied N:P ratio was 20:40.

Tomar *et al.* (1993) observed that the application of phosphate-solubilizing bacteria significantly increased the seed yield over the control from 9.5 in the 1st year to 22.5 % in the 2nd year. Influence on the pods/plant and seed index was also evident. Seed yield of blackgram increased with increasing levels of phosphate. Shah *et al.*, 1994 observed that phosphorus application irrespective of its doses increased the grain, straw and biological yields significantly. This may be due to significant improvement in growth and yield attributes due to P application.

According to Selvi and Ramaswami (1995) the seed yield of blackgram was highest in plots receiving RDF + 25 kg $ZnSO_4$ only once in a cropping period. Mahanta

and Borah (1998) observed that poultry manure and neem cake were most effective in increasing the yield of blackgram.

2.7.4.4 Soil status after blackgram cropping as influenced by INM

Morey and Bagde (1982) reported that among legume squences, urd – wheat sequence gave maximum wheat yield. The residual value of legume nitrogen to wheat in terms of fertilizer N was 28.50, 36.00 and 30.40 kg ha^{-1} for mung, urd and groundnut, respectively. Dwivedi *et al.* in 1993 reported that application of N, P and Mo increased the grain yields of wheat due to the residual effect of *Rhizobium* inoculation to the preceding blackgram crop.

Kumar and Prasad (1999) observed that legumes in general and blackgram in particular added higher biomass in soil system but the same was depleted after the harvest of wheat. Maximum value of organic carbon was recorded after blackgram in both the years. Since the crops were raised without addition of organic manure, a general decrease in organic carbon was noticed. Blackgram - wheat maintained higher soil available P than other treatements. A fairly good enhancement in available K was recorded in its initial stages due to continuous application of K in all the crops. Sequences having legumes left behind more K in soil than cereal sequences. The total production in terms of wheat equivalent yield clearly demonstrated the superiority of legume – wheat sequences.

2.7.5 Wheat

2.7.5.1 Effect of INM on wheat cropping

Wheat responded well to *Azospirillum* application when coupled with higher (100 %) N level (Okon and Kapulinth, 1986). Integration of organic sources like FYM, poultry manure and piggery manures over years on the same site produced better results in wheat than that of RDF. Negi *et al.* (1992) observed that integration of farmyard manure and P to wheat gave significantly higher gross returns.

Patel *et al.* (1992) stated that incorporation of compost prepared with calotropis and castor cake increased the availability of N and P. Raghuwanshi and Umat (1994) observed that wheat yield was highest (4.70 t) when inorganic fertilizer @ 50 % of NPK and 50 % N was applied as FYM. It was suggested that applying 25-50 % of N as organic fertilizer in *kharif* may be economic and stabilize yield during a cropping sequence. Hegde in 1998 opined that the total productivity of the pearl millet - wheat cropping system showed that farmyard manure or green manure could easily substitute

50% N needs of pearl millet. Integration of fertilizers and organic sources helps in long-term sustainability.

2.7.5.2 Dry matter accumulation of wheat in INM

Ranwa *et al.* in 1999 opined that all levels of organic manures improved the yield attributes over no organic matter. Productivity of the soil and agronomic characteristics were best expressed in vermicompost @ 10 t ha^{-1} along with 100 kg N ha^{-1} but statistical parity was observed in treatment sample with 7.5 t ha^{-1}.

2.7.5.3 Yield of wheat as influenced by INM

Negi *et al.* (1992) observed that the application of farmyard manure and P to wheat gave significantly higher grain yield. Studying the effect of fertilizer and *Azospirillum* on grain yield of rainfed wheat, Sawarkar and Goydani (1996) suggested that the recommended dose of fertilizers may be reduced. Kumar and Kumar (1997) reported that highest grain yields of wheat (7.04 t ha^{-1}) were obtained with 125 % of recommended NPK + Zn + FYM.Ranwa *et al.* in 1999 opined that all levels of organic manures improved the yield attributes and grain, straw and biological yields over no organic matter.

2.7.5.4 Role of biofertilizers in wheat cropping

Chen (1993) observed nitrogen fixation by *Azospirillum brasilense* and *Azospirillum caulinodans* in para nodules induced on wheat roots.

2.7.5.5 Influence of INM after wheat cropping on the physicochemical status of soil

Singh *et al.* (1998) noticed that wheat yield was greatest from the residual effects of poultry manure alone or with NPK.

2.7.6 Greengram

2.7.6.1 Dry matter accumulation of greengram as influenced by INM

Srivastava and Verma (1982) reported higher dry-matter production with the application of farmyard manure or fertilizers. Reddy *et al.* (1992) found that application of farmyard manure @ 5 tonnes ha^{-1} along with 20 kg N and 20 kg P ha^{-1} recorded highest dry matter during reproductive stage. Sharma *et al.* in 1994 observed that dry matter yields at maturity was highest with 60 kg P_2O_5 ha^{-1} and with hoeing and IAA.

Santhi and Kothandaraman (1995) found that inoculation with VAM increased the dry matter yield. Mandal *et al.* in 1997 experimented on effect of various combinations of rock phosphate with natural (including cattle urine) and synthetic organic substances on agronomic parameters of greengram. They found that whey treated and cycocel treated combinations showed highest dry matter in greengram.

2.7.6.2 Nodulation of greengram as influenced by INM

Srivastava and Varma (1982) obtained higher root nodules/plant in inoculated plots. Patel *et al.* (1984) also reported similar trends of significance with the application of N @ 10 kg ha^{-1}, which might have been resulted from greater bacterial activity. They also observed (1991) that the *Rhizobium* culture showed significant effect on the number of nodules/plant at three stages of plant growth. Sarkar and Banik (1991) stated that the greengram responds to P fertilization as it enhances root growth and improves nodulation, which ultimately results in efficient N fixation and higher yield.

Ardeshna *et al.* (1993) found that the application of N @ 10 kg ha^{-1} produced highest number of root nodules/plant. *Rhizobium* inoculation significantly increased the grain yield, the increase being 9.6 % compared with no inoculation. Chovatia *et al.* (1993) inferred that *Rhizobium* inoculation significantly increased the growth, yield attributes and yield, which can be attributed to better nodulation. Sarkar *et al.* (1993) reported that inoculation of *Rhizobium* markedly increased the nodule number compared with no inoculation. Application of N alone or in combination with *Rhizobium* inoculation might be accounted for lesser N fixation or inadequate reserve after meeting the requirement of greengram crop grown in summer with irrigation.

Singh *et al.* (1993) observed that inoculation increased the effective number of nodules. Sharma *et al.* in 1994 observed that nodule count at 50 DAS was highest with 60 kg P_2O_5 ha^{-1} and with hoeing and IAA. Baruah *et al.* (1995) reported that inoculation with *Rhizobium* alone stimulated nodulation and nitrogen fixation of greengram. Dual inoculation with VAM and *Rhizobium* further significantly increased nodulation and N_2 fixation. Between the two sources of P, dual inoculation was better with single super phosphate as compared to mussorie rock phosphate.

2.7.6.3 Yield of greengram as influenced by INM

Rhizobium inoculation to legumes increases the yield and has other beneficial effects also (Rao, 1980). Srivastava and Varma (1982) obtained similar results in inoculated plots, which showed significantly greater plant height, number of

branches/plant and pods/plant, which ultimately improved the grain yield. Patel *et al.* (1984) also reported that application of N @ 20 kg ha^{-1} yielded as high as that of 30 kg ha^{-1}, but significantly higher than 10 kg ha^{-1}. Patel and Patel (1991) observed that the *Rhizobium* culture did not show any effect on yield components. Yield attributes were found to be increased with increasing levels of phosphorus from 0 to 60 kg ha^{-1}.

Sarkar and Banik (1991) stated that the greengram responds to P fertilization resulting in efficient N fixation and higher yield. Chovatia *et al.* (1993) inferred that the higher yield in 15 February and 2 March sowings were mainly owing to favourable temperatures during their growth period. *Rhizobium* inoculation significantly increased the growth, yield attributes and yield, which can be attributed to better nodulation. Meena *et al.* (1993) observed that application of N to preceding wheat had a significant effect on all the growth, yield and yield-attributing characters. The increase in grain yield due to 120 kg N ha^{-1} was 35 % compared with the control.

Singh *et al.* (1993) opined that inoculation increased seed yields and uptake of N and P in greengram. Singh *et al.* in 1993 reported that inoculation and N:P:K = 20:40:40, increased the seed yield and economic return in greengram. Gill *et al.* (1994) observed that farmyard manure @ 6 tonnes ha^{-1} + 50% recommended inorganic fertilizers was significantly more than 100% recommended inorganic fertilizer in producing grain yield of wheat.

Santhi and Kothandaraman (1995) found that the yield increase with the soil inoculation were highest when 25 kg P_2O_5 was applied. Dudhat *et al.* (1996) found that wheat yield was highest with castor cake + recommended N, P fertilizers while greengram seed yield was higher from the residual effects of FYM and inorganic fertilizers. Shukla and Dikshit (1996) observed that the increased rate of P_2O_5 upto 40 kg ha^{-1} and *Rhizobium* inoculation increased the seed yield.

According to Ramamoorthy and Arokiaraj (1997) maximum seed yield and yield components of greengram were observed with 25 kg P_2O_5 ha^{-1} as MRP + seed inoculation with phosphobacteria. Mahanta and Borah (1998) observed that poultry manure and neem cake were most effective in increasing the yield of greengram. According to Soni *et al.* (1999) phosphorus significantly increased the grain yield of summer mungbean. The treatment with 40 kg P_2O_5 ha^{-1} resulted in higher grain yield than 20 kg P_2O_5 ha^{-1} and the control.

2.7.6.4 Physicochemical status of soil after greengram cropping in INM

Meena *et al.* (1993) observed that application of N to preceding wheat had a significant residual effect on all the growth, yield and yield-attributing characters, and N and P uptake by greengram. Sarkar *et al.* (1993) opined that low N status in soil under application of N alone or in combination with *Rhizobium* inoculation might be accounted for lesser N fixation or inadequate reserve after meeting the requirement of greengram crop grown in summer with irrigation.

Laddha and Totawat (1998) observed that incorporation of FYM and phosphatic fertilizers improved the physical conditions of the soil and the stored soil moisture profile.

MATERIALS & METHODS

CHAPTER 3

MATERIALS AND METHODS

Two field experiments were conducted during July-June of 1997-98 and 1998-99 with two cropping systems taken up in two successive years in the alluvial soils of Allahabad. The materials and methods involved in the study are presented in this chapter.

3.1 Experimental Site

The field experiments were conducted at the Crop Research Farm of the Department of Agronomy, Allahabad Agricultural Institute, Allahabad. The site is located at 25°.57' North latitude and 81°.50' East longitude at an altitude of 98 m above mean sea level.

3.2 Climate

Meteorological data recorded at Allahabad during the experimental period are presented in Figures 3.1 and 3.2. In the first cropping year (1997-98) the mean maximum and minimum temperature was 31.58 °C and 19.31°C, the mean relative humidity ranged between 85.95 and 45.95 per cent and total rainfall of 606.60 mm was recorded in 86 days. The corresponding figures respectively for the second cropping year (1998-99) were 32.29 °C, 19.80 °C, 81.11 and 38.68 percent, 706.50 mm in 82 days.

3.3 Soil

Both the field experiments were accommodated in adjacent compact plots with almost uniform fertility status. The alluvial sandy-loam textured soil was low in organic carbon, nitrogen content and phosphorus and high in potassium. The physico-chemical properties of the soil of the experimental site are presented in Table 3.1.

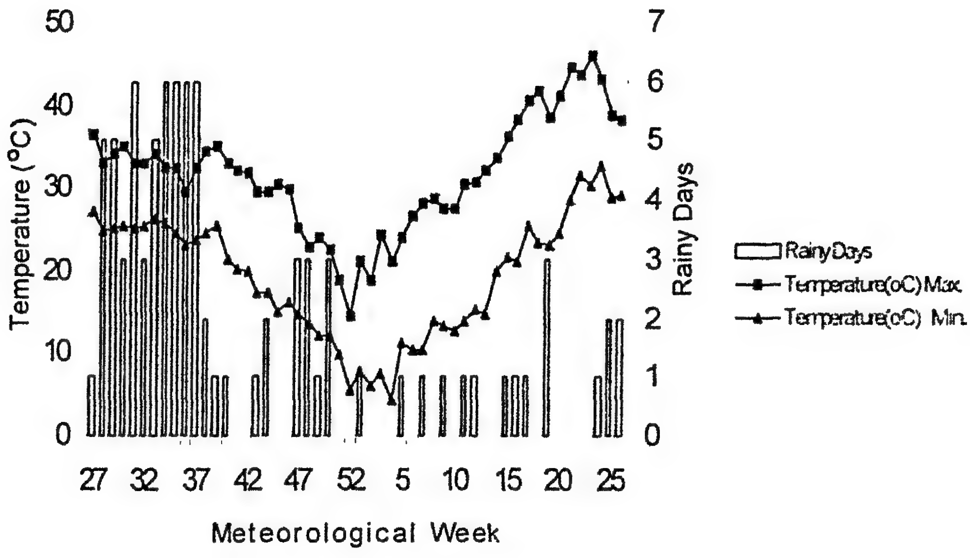


Fig. 3.1(a) **Weekly mean maximum and minimum temperature, rainy days during the cropping period of 1997-98**

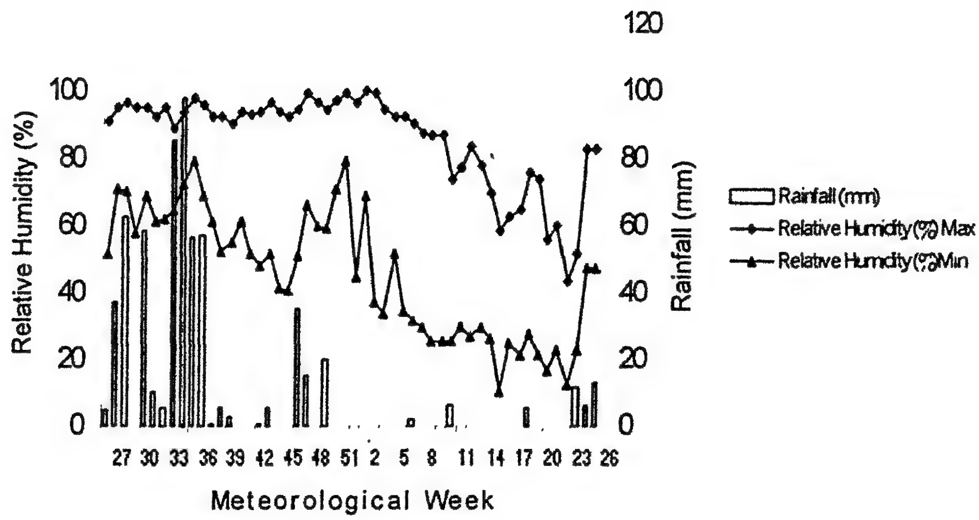


Fig. 3.1(b) **Weekly mean maximum and minimum relative humidity and rainfall during the cropping period of 1997-98**

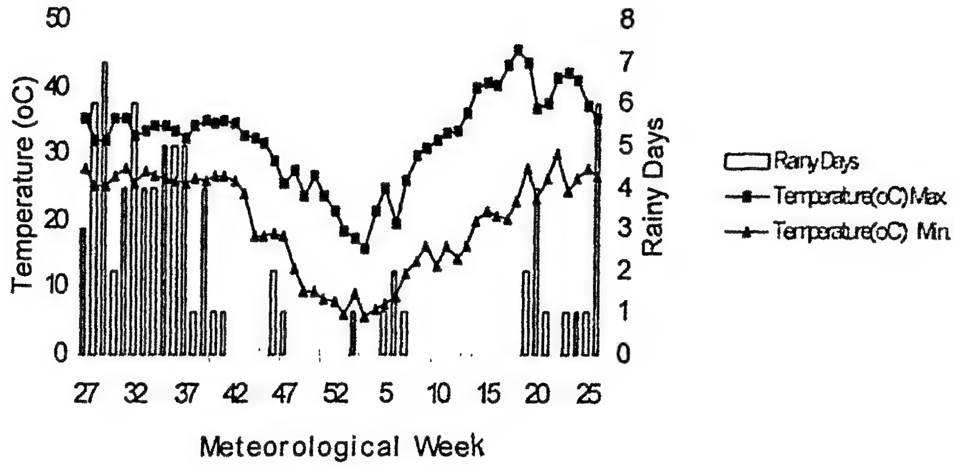


Fig. 3.2(a) Weekly mean maximum and minimum temperature, rainy days during the cropping period of 1998-99

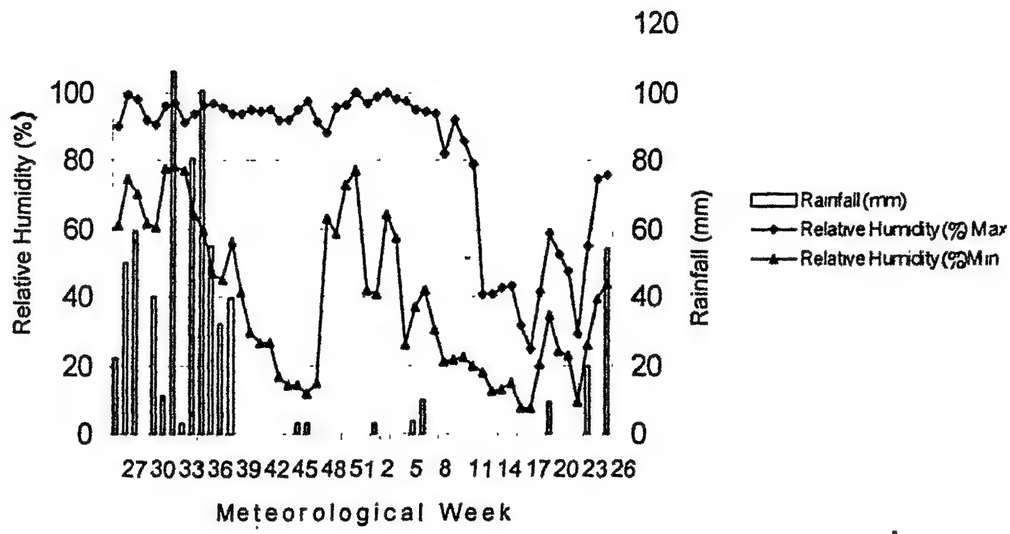


Fig. 3.2(b) Weekly mean maximum and minimum relative humidity and rainfall during the cropping period of 1998-99

Table 3.1 Physical and chemical properties of the soil of experimental fields for a depth of 0-30 cm.

Particulars	Values		Method
	Experiment 1	Experiment 2	
Physical properties			
Particle size distribution (%)			
Sand	58.03	53.20	Bouyoucos hydrometer
Silt	26.35	28.20	(Piper, 1946)
Clay	15.62	18.60	
Chemical properties			
pH	7.40	7.50	Glass electrode pH meter (Jackson, 1973)
Organic carbon (%)	0.34	0.39	Walkley-Black method (Jackson, 1973)
Avaialble N (kg ha^{-1})	208.25	219.00	Alkaline $KMnO_4$ (Subbaiah and Asija,1956)
Available P_2O_5 (kg ha^{-1})	49.20	41.00	NH_4F-extraction (Jackson, 1973)
Available K_2O (kg ha^{-1})	315.84	383.09	Flame Photometery (Jackson, 1973)
Electrical Conductivity$_{25}$ (dS m^{-1})	0.45	0.50	Conductivity bridge (Jackson, 1973)

Table 3.2 Chemical constituents* of organic sources used in the experiments

Source	N (%)	P_2O_5 (%)	K_2O (%)	C:N
Farm compost	1.58	0.66	0.99	25.36
Poultry manure (litter)	1.77	1.82	1.57	19.08
Vermicompost	1.60	4.46	0.80	15.49

* *Organics in sustaining fertility.*(1998) The University of Agricultural Sciences, Dharwad, India

3.4 Cropping history of the sites

The cropping history of both the experimental sites for the preceding five years are recorded in Table 3.3

Table 3. 3 Cropping history of plot no. 500 (experiment 1) and plot no. 600 (experiment 2)

Year	Experiment 1 (plot 500)			Experiment 2 (plot 600)		
	Kharif	*Rabi*	*Zaid*	*Kharif*	*Rabi*	*Zaid*
1992-93	Greengram	Wheat	-	Groundnut	Wheat	-
1993-94	Blackgram	Wheat	-	Groundnut	Wheat	-
1994-95	Greengram	Wheat	-	Blackgram	Wheat	-
1995-96	Blackgram	Wheat	-	Groundnut	Wheat	-
1996-97	Greengram	Wheat	-	Groundnut	Wheat	-

3.5 Experimental details

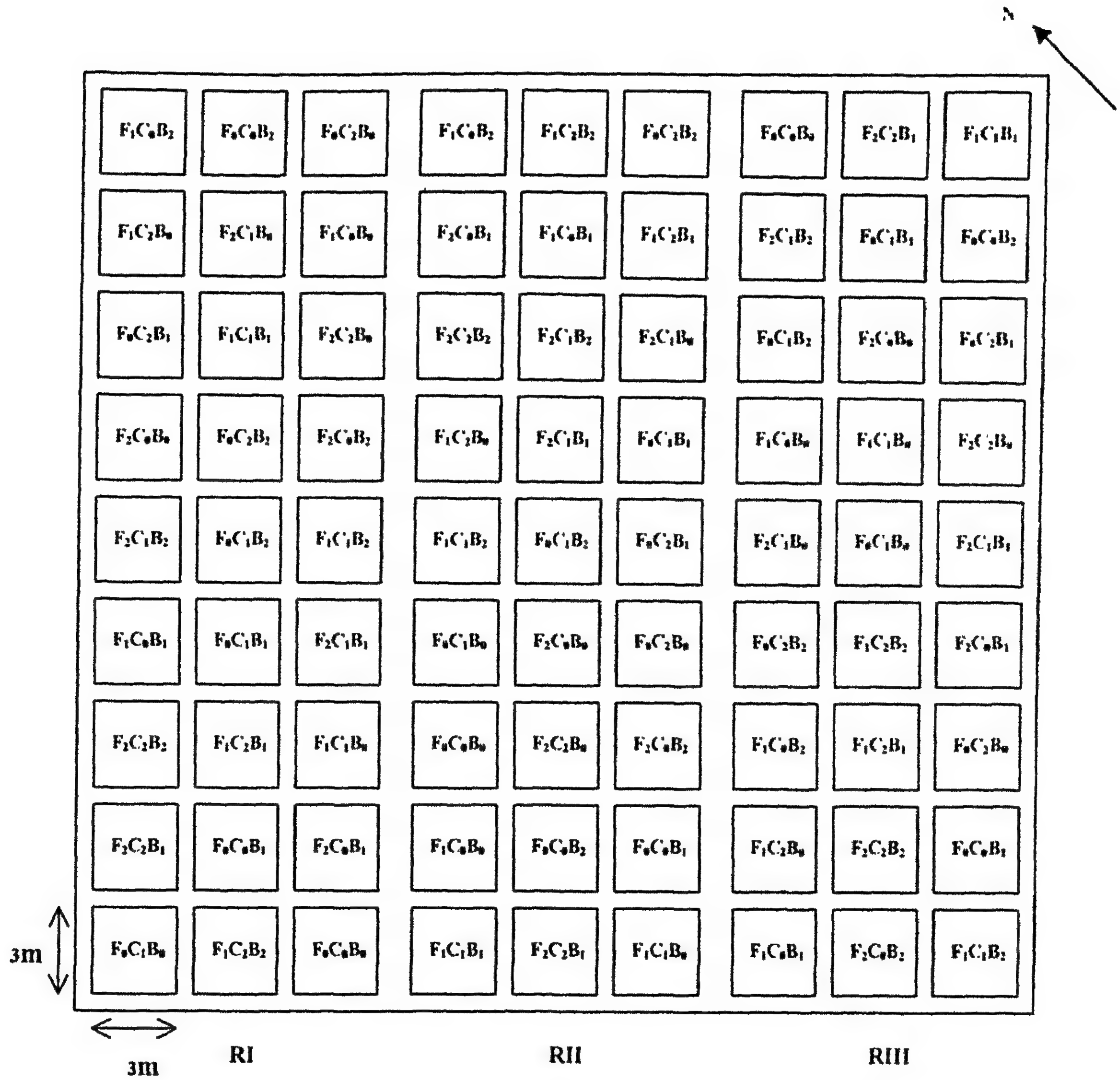
The details of the field experiments conducted are given below.

Experiment 1: Influence of integrated nutrient management on oilseed and fodder based legume cropping system

Kharif	*Rabi*	*Zaid*
Soybean	Mustard	Fodder cowpea
(*Glycine max* L. Merr.)	(*Brassica juncea* L. Czern. Coss.)	(*Vigna unguiculata* L. Walp.)

Experiment 2: Influence of integrated nutrient management on pulse-based cropping system.

Kharif	*Rabi*	*Zaid*
Blackgram	Wheat	Greengram
(*Vigna mungo* L.)	(*Triticum aestivum* L.)	(*Vigna radiata* L. Wilezeck.)



Treatment combinations: 27

Fertilizer (NPK) dose (F): 3 levels

F_0 Nil application

F_1 33% recommended dose (RDF)

F_2 100% recommended dose (RDF)

Forms of organic manures (C): 3

C_0 Nil application

C_1 Farm compost (FC) @ 5 t ha $^{-1}$ + Vermicompost (VC) @ 1 t ha $^{-1}$

C_2 Farm compost (FC) @ 5 t ha $^{-1}$ + Poultry manure (PM) @ 0.5 t ha $^{-1}$

Forms of biofertilizers and/or foliar application of organic manure (B): 3

B_0 Nil application

B_1 Phosphate solubilizing bacteria (PSB) + *Rhizobium* (Rhz) or *Azospirillum* (Azsp)

B_2 Phosphate solubilizing bacteria (PSB) + 2 foliar application of 33% cow's urine (CU)

Design: Randomized complete block

Replication: 3

Total number of plots: 81

Plot size (not to scale)

Gross: 13.03 m^2

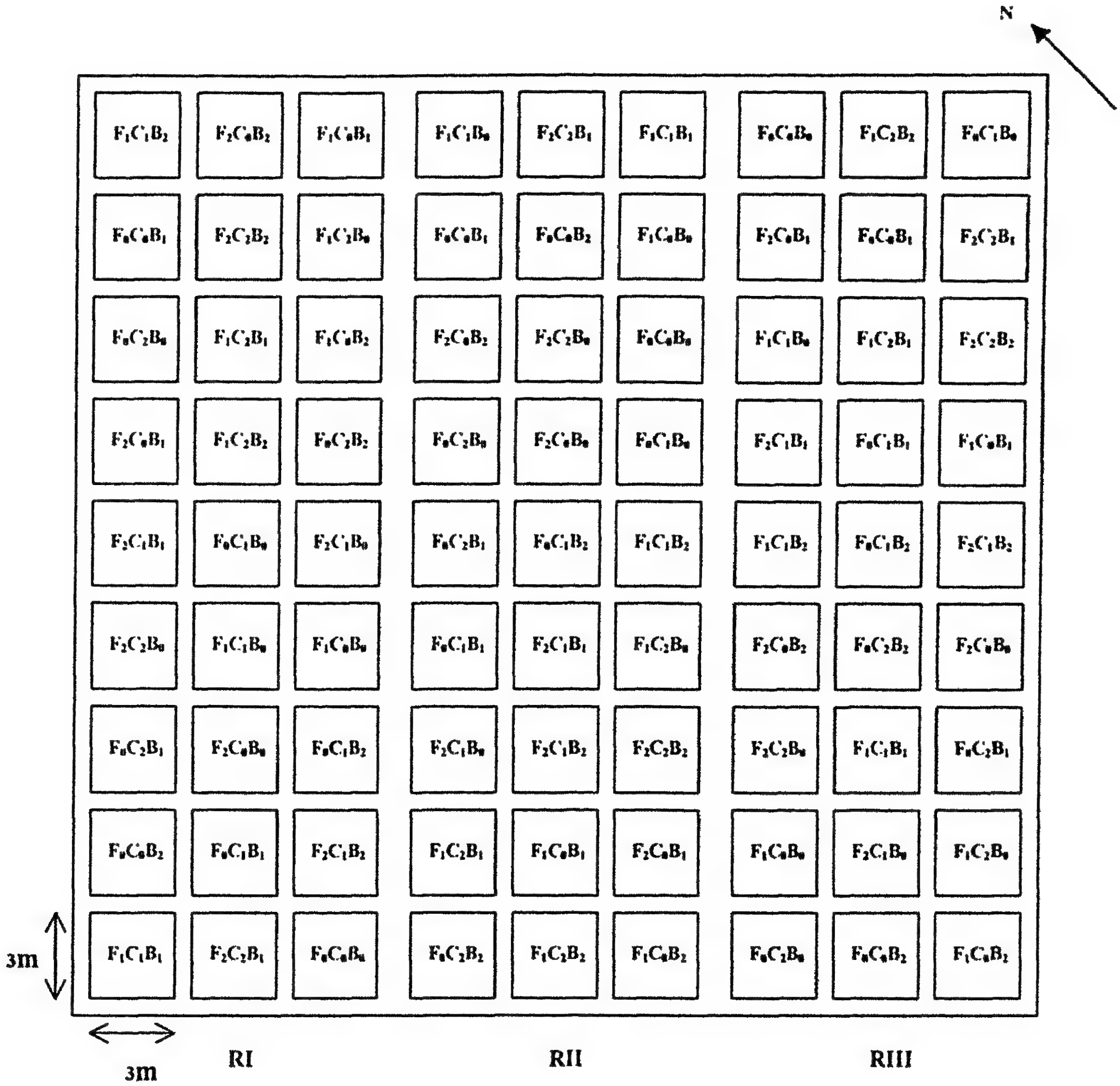
Net: 9.00 m^2

Spacing

inter plots: 40 cm

inter replications: 75 cm

Fig.3. 3 Layout plan of field experiment I



Treatment combinations: 27
Fertilizer (NPK) dose (F): 3 levels
- F_0 Nil application
- F_1 33% recommended dose (RDF)
- F_2 100% recommended dose (RDF)

Forms of organic manures (C): 3
- C_0 Nil application
- C_1 Farm compost (FC) @ 5 t ha $^{-1}$ + Vermicompost (VC) @ 1 t ha $^{-1}$
- C_2 Farm compost (FC) @ 5 t ha $^{-1}$ + Poultry manure (PM) @ 0.5 t ha $^{-1}$

Forms of biofertilizers and/or foliar application of organic manure (B): 3
- B_0 Nil application
- B_1 Phosphate solubilizing bacteria (PSB) + *Rhizobium* (Rhz) or *Azospirillum* (Azsp)
- B_2 Phosphate solubilizing bacteria (PSB) + 2 foliar application of 33% cow's urine (CU)

Design: Randomized complete block
Replication: 3
Total number of plots: 81
Plot size (not to scale)
Gross: 13.03 m^2
Net: 9.00 m^2
Spacing
inter plots : 40 cm
inter replications : 75 cm

Fig.3. 4 Layout plan of field experiment 2

3.5 Cultural operations

3.6.1 Field preparation

The experimental field was prepared prior to each crop by using tractor drawn disc plough followed by cross harrowings, cultivator and planker.

3.6.2 Fertilizer application and interculture

The manures and basal dose of fertilizer was administered by placement method into furrows and incorporated well prior to sowing. Nitrogen (N), Phosphorus (P_2O_5) and Potassium (K_2O) in the form of urea, single super phosphate or di-ammonium phosphate and muriate of potash respectively were used. The plots with CU treatment were administered foliar spray of 33 per cent CU at 25 and 45 DAS ($\pm$ 5 days) to each crop in both the years. One to two hand weeding was administered as per the recommendation for each crop during the critical phase. The dosage of nutrients for fertilizer application for each crop component in the two systems are given in Table 3.4

Table 3.4 Nutrient dose for fertilizer application (based on treatments) administered to crops in the two experiments

Crops	100% of recommended dose (kg ha $^{-1}$)			33% of recommended dose (kg ha $^{-1}$)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Experiment 1						
Soybean*	150	75	30	50	25	10
Mustard*	90	60	45	30	20	15
Cowpea	20	50	20	6.66	16.66	6.66
Experiment 2						
Blackgram	20	60	-	6.66	20	-
Wheat*	120	60	45	40	20	15
Greengram	20	50	20	6.66	16.66	6.66

*Split application of N

3.6.3 Seed treatment and sowing

The seed for plots with treatment of biofertilizers were separately handled, inoculated and sown. The legume species, as per the treatments, were inoculated with appropriate rhizobium strain cultures and/or phosphate solubilizing bacteria. Similarly, *Azospirillum* and/or phosphate solubilizing bacteria cultures, as per treatments, were used for inoculating the seeds of non-legumes, *viz.*, mustard and wheat crops. The variety and spacing of the component crops in the two experiments are given in Table 3.5.

Table 3.5 Variety and spacing adopted for test crops

Experiment/Crop	Variety	Spacing (cm)
Experiment 1		
Soybean	PK-416*	42.80 x 10.00
Mustard	Pusa bold	37.50 x 5.00
Fodder Cowpea	EC-4216	30.00 x 5.00
Experiment 2		
Blackgram	PU-35	37.50 x 5.00
Wheat	WH-542	25.00 x 5.00
Greengram	PM-2	30.00 x 5.00

*2nd year variety used PK -327

3.6.4 Irrigation

The crop components raised during the *rabi* and *zaid* seasons were administered irrigation based on the critical stages and soil moisture status. The frequency of irrigation followed is given in the Tables 3.6 and 3.7 consisting of the calendar of operations.

3.6.5 Plant protection

Prophylactic and control measures against target pests and diseases were undertaken for crop trials raised during *kharif* and *rabi* seasons .The dates are recorded in the calendar of operation Tables 3.5 and 3.6.

Table 3.6.Calendar of cultural operations followed in Experiment 1 during 1997-98 and 1998-99

Operations	Soybean		Mustard		Fodder Cowpea	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Field preparation	June 30	June 30	Nov 1	Nov 4	April 12	April 15
Layout	July 2	July 1	Nov 2	Nov 5	April 13	April 16
Manuring	July 3	July 2	Nov 4	Nov 6	April 13	April 17
.Sowing	July 3	July 2	Nov 4	Nov 6	April 13	April 17
1st interculture	July 23	July 20	Nov 27	Dec 3	May 10	May 11
1st top dressing	-	Aug 4	-	-	-	-
No. of irrigations	-	-	2	2	7	7
2nd interculture	Aug 7	Aug 19	Dec 19	Dec 22	-	-
2nd top dressing	Aug 12	Aug 22	Dec 20	Dec 22	-	-
1st foliar spray (treatment plots)	July 24	July 30	Dec 21	Dec 22	May 9	May 13
2nd foliar spray (treatment plots)	Aug 20	Aug 12	Jan 1	Jan 16	May 21	May 25
	July 26	Aug 13	Jan 28	Jan 31	-	-
Plant protection	Aug 4	Aug 28	Feb 17	Feb 12	-	-
	-	-	-	Feb 27	-	-
Harvesting	Oct 30	Oct 22	Mar 18	Mar 19	June 18	June 22

Table 3.7 Calendar of cultural operations followed in Experiment 2 during 1997-98 and 1998-99

Operations	Blackgram		Wheat		Greengram	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Field preparation	June 30	June 30	Nov 1	Nov 11	April 11	April 15
Layout	July 1	July 3	Nov 11	Nov 13	April 12	April 15
Manuring	July 2	July 4	Nov 14	Nov 14	April 12	April 16
Sowing	July 2	July 4	Nov 14	Nov 14	April 12	April 16
1st interculture	July 22	July 31	Nov 28	Dec 22	May 7	May 8
1st top dressing	-	-	-	-	-	-
No. of irrigations	-	-	6	6	7	7
2nd interculture	Aug 16	Aug 17	Dec 16	Dec 25	-	-
2nd top dressing	-	-	Dec 21	Jan 2	-	-
1st foliar spray (treatment plots)	July 24	July 30	Dec 21	Jan 6	May 9	May 13
2nd foliar spray (treatment plots)	Aug 20	Aug 12	Jan 1	Jan 29	May 21	May 25
Plant protection	July 26	Sep 14	-	Mar 15	-	-
	Aug 4	-	-	-	-	-
	Sep 1	-	-	-	-	-
Harvesting – 1st pick	Sep 18	Sep 28	April 4	April 3	June 5	June 9
2nd pick	Oct 5	Oct 21	-	-	June 14	June 18
3rd pick	-	-	-	-	June 30	July 2

3.7 Observations

3.7.1 Pre-harvest observations

Observations on dry matter accumulation were recorded at fortnightly intervals for each crop component in both the experiments. Five plants per plot were collected from each of the 81 plots at 15, 30, 45, 60, 75, 90 and 105 days after sowing. The number of observations per crop component varied from 3 in the case of greengram to 7 in the case of wheat. The legume crop components were subjected to root nodule count per plant at similar interval of fortnight. The 5 plants sampled for dry weight were used for this observation. The frequency of this parameter varied from 3 to 5, depending on the crop duration and nodulation habit.

3.7.2 Post harvest observation

The yield parameters of the six crop components in the two cropping systems were recorded based on the type of the crop. Number of pods per plant in the case of blackgram, greengram, soybean and mustard crops were recorded. In wheat the number of effective tillers per hill were counted. The test weight and total grain yield per

hectare were recorded in all crops except in fodder cowpea in which the herbage yield was measured.

3.7.3 Chemical analysis of soil and plant

3.7.3.1 Soil analysis

Soil samples were taken before the experiment and after the harvest of each of the component crops in both the experiments. A representative soil sample of the field obtained by mixing the soil samples collected randomly from the different points of the field was used for initial analysis.

The initial analysis was conducted for physical composition, pH, EC_{25}, organic carbon, available phosphorus, and potassium. Plot-wise analysis of soil samples for pH, EC_{25}, organic carbon, available phosphorus and potassium were conducted for each of the 81 plots in the two experiments after the harvest of each component crop in the cropping system. The methods followed for the analysis of soil physical and chemical properties are given in Table 3.1.

3.7.3.2 Plant analysis

The second year's harvested grain and dried fodder cowpea shoots from experiment 1 was analysed for carbohydrate, protein and/or oil content. The methods followed for chemical analysis are referred in Table 3.8

Table 3.8 Procedure used for chemical analysis of grain and fodder shoots.

S.No.	Particulars	Method	Reference
1	Carbohydrate	Anthrone method	Hedge & Hofreiter,1962
2	Protein	Micro-kjeldahl method	Pellett & Young, 1980
3	Oil	Soxhlet mehtod	Sadasivan & Manickam, 1992

3.8 Statistical analysis

Randomized complete block design was used for both the 3 x 3 x 3 factorial experiments. The experimental data were analysed statistically by applying the analysis of variance technique appropriate to the design as described by Snedecor and Cochran (1967), Gomez and Gomez (1984) and Panse and Sukhatme (1995). Significance was tested by F-test tabulated values at 5% level of probability (Fisher and Yates, 1957) for appropriate degrees of freedom. The standard error of difference and least significant

difference (critical difference) has been provided for statistical analyses wherever F-test was significant.

Statistical analysis of the data was carried out using Statistix PC DOS Version 2.0 Software package. The graphics presentation has been prepared by using MS Word 2000 Software package. The skeleton of analysis of variance with their corresponding degrees of freedom is given in Table 3.9.

Table 3.9 Skeleton of ANOVA table

Source of Variation	Degree of Freedom*	Sum of Squares	Mean Square	Computed F	Tabular F (5%)
Replication	r – 1				
Treatment	f c b – 1				
Fertlizer (F)	f- 1				
Organic manure (C)	c- 1				
Biofertilizer (B)	b - 1				
F x C	(f – 1) (c – 1)				
F x B	(f – 1) (b – 1)				
C x B	(c – 1) (b – 1)				
F x C x B	(f – 1) (c – 1) (b - 1)				
Error	(r – 1) (f c b – 1)				
Total	(r f c b – 1)				

*r = number of replication; f, c, and b are levels of the three factors F, C, and B respectively.

RESULTS

CHAPTER 4

RESULTS

Two field experiments were conducted to study the influence of INM in legume based cropping systems on the various agronomic and soil characteristics. The results of the investigation are presented in this chapter.

4.1 Experiment 1: (Soybean – Mustard – Fodder cowpea system)
Crop component 1: Soybean

4.1.1 Dry matter accumulation

4.1.1.1 Fertilizer levels

In both the years (1997-98 & 1998-99) highly significant difference was observed in plots with 100% RDF over control with regard to dry matter accumulation, throughout the crop period except at 30 DAS in the second year (Table 4.01). The per plant dry weight values in treatments with 33% RDF were statistically at par at 15 and 75 DAS in both years. Further, these plots also recorded significant difference over the control during the first year at 45 DAS, and during both years at 60 and 90 DAS stages.

4.1.1.2 Manurial forms

The FC + PM combination recorded higher dry weight during second year (Table 4.01) at 15, 45 and 60 DAS, and significantly higher values during both years at 75 and 90 DAS. The FC + VC combination showed similar trend during second year at 15 and 60 DAS, during both years at 30 DAS and was statistically at par with the FC + PM treatment at 75 and 90 DAS during the second year. At 75 and 90 DAS during the first year the FC + VC treatment recorded significantly higher values over control.

4.1.1.3 Biofertilizer and/or organic spray

Both the Rhz + PSB and PSB + CU treatments significantly effected the plant dry-weight at 15 and 30 DAS during the first year, at 75 DAS during the second year and at 90 DAS during both the years. However, highest values were recorded in either of these treatments during the entire experimental period (Table 4.01).

Table 4.01 Effect of INM on dry weight of soybean (g/plant) during 1997-98 and 1998-99

Factors	15 DAS		30DAS		45DAS		60DAS		75DAS		90DAS	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Levels of Fertilizers (F):												
F_0	0.193	0.445	1.047	0.849	2.864	2.381	15.25	8.882	24.94	20.21	34.88	26.85
F_1	0.225	0.519	1.103	1.010	3.741	3.240	17.22	11.30	35.51	28.50	55.04	39.78
F_2	0.242	0.549	1.332	1.203	4.954	4.213	24.06	16.39	38.12	29.72	66.13	53.26
	*	*	*	NS	*	*	*	*	*	*	*	*
Forms of manure (C):												
C_0	0.221	0.509	1.132	1.015	3.825	3.304	17.93	11.62	27.67	19.64	44.27	29.68
C_1	0.218	0.484	1.235	1.032	3.428	3.100	19.08	12.81	32.44	28.23	51.20	43.82
C_2	0.220	0.519	1.115	1.015	4.311	3.429	19.51	12.09	38.47	30.56	60.58	46.39
	NS	NS	NS	NS	NS	NS	NS	NS	*	*	*	*
Biofertilizers and/or organic spray (B):												
B_0	0.200	0.505	1.037	0.952	3.914	3.029	18.51	11.79	29.86	22.45	47.34	36.67
B_1	0.225	0.519	1.137	1.085	3.188	3.074	20.63	11.76	31.94	27.13	54.84	40.80
B_2	0.234	0.489	1.308	1.025	4.461	3.373	17.74	12.97	36.77	28.85	53.88	42.42
	*	NS	*	NS	NS	NS	NS	NS	NS	*	*	*
SEd ±	0.013	0.022	0.106	0.088	0.606	0.410	2.174	1.455	2.883	1.913	2.460	2.444
CD(0.05)	0.027	0.045	0.214	-	1.217	0.823	4.363	2.919	5.785	3.839	4.937	4.904
FxC FxB CxB:												
SEd ±	0.023	0.039	0.184	0.152	1.051	0.710	3.966	2.520	4.994	3.314	4.262	4.233
CD(0.05)	0.047	0.078	0.370	0.306	2.109	1.426	7.558	5.057	10.02	6.651	8.553	8.495

*Significant at P = 0.05 NS = non-significant

4.1.1.4 Interaction effect of fertilizer levels and manurial forms

Table 4.01.1(a) Effect of interaction of fertilizer levels and manurial forms on dry weight of soybean (g/plant) at 15 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.196	0.198	0.186	0.193	0.396	0.470	0471	0.446
F_1	0.227	0.222	0.227	0.225	0.547	0.473	0.538	0.519
F_2	0.243	0.236	0.249	0.243	0.587	0.511	0.550	0.549
Mean	0.222	0.219	0.220		0.510	0.485	0.520	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.023	0.047			0.039	0.078	

At 15 DAS during the 1st year the treatment combination 100% RDF with FC + PM recorded significantly higher over over control [Table 4.01.1(a)]. The dry weight values were at par in plots treated with 100% RDF alone and with FC + VC, 33% RDF alone and with FC + VC and FC + PM combinations.

In the second year at 15 DAS 100% RDF treatment recorded significant dry weight values over control. The treatments 100% RDF with FC + PM and with FC + VC, and 33% RDF alone and with FC + PM were statistically at par.

Table 4.01.1(b) Effect of interaction of fertilizer levels and manurial forms on dry weight of soybean plant (g/plant) at 30 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.98	1.05	1.12	1.05	0.67	0.89	0.99	0.85
F_1	1.08	1.19	1.03	1.10	1.10	0.98	0.95	1.01
F_2	1.34	1.47	1.19	1.33	1.27	1.24	1.10	1.20
Mean	1.13	1.24	1.11		1.02	1.03	1.02	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.18	0.37			0.15	0.31	

In first year the treatment 100% RDF with FC + VC recorded highest values and statstically comparative figures were observed in 100% RDF alone and with FC + PM, 33% with FC + VC and FC + PM alone [Table 4.01.1(b)].

A similar trend was perceptible in the second year, except that 33% RDF was also found to be at par.

In the 1st year at 45 DAS 100% RDF showed the maximum dry weight per plant. The treatments 100% RDF with FC + PM and with FC + VC, 33% RDF with FC + PM and FC + PM without any fertilizer were comparable [Table 4.01.1(c)].

Table 4.01.1(c) **Effect of interaction of fertilizer levels and manurial forms on dry weight of soybean (g/plant) at 45 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	2.13	2.75	3.70	2.86	1.75	2.61	2.78	2.38
F_1	3.66	3.38	4.18	3.74	3.61	2.63	3.48	3.24
F_2	5.68	4.15	5.05	4.96	4.55	4.06	4.03	4.21
Mean	3.82	3.43	4.31		3.30	3.10	3.43	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		1.05	2.11			0.71	1.43	

In the second year at 45 DAS 100% RDF was significantly effective in dry matter accumulation. FC + VC with 100% RDF and FC + PM in combination with 100% as well as 33% and 33% RDF alone were statistically at par.

Table 4.01.1(d) **Effect of interaction of fertilizer levels and manurial forms on dry weight of soybean (g/plant) at 60 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	11.89	17.29	16.55	15.24	8.76	8.74	8.97	8.82
F_1	18.66	15.68	17.31	17.22	10.18	13.24	10.48	11.30
F_2	23.23	24.26	24.68	24.06	15.91	16.45	16.82	16.39
Mean	17.93	19.08	19.51		11.62	12.81	12.09	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		3.77	7.56			2.52	5.06	

At 60 DAS during 1st year it was apparent that the 100% RDF combined with FC + PM and FC + VC were best treatments [Table 4.01.1(d)]. Statistical analysis revealed that treatments 100 RDF alone, 33% RDF alone and in combination with FC + PM and FC + VC alone were comparable.

During 2nd year at 60 DAS exactly similar trend was observed with the 100% RDF combinations and the treatment 33% RDF with FC + VC was comparable.

Table 4.01.1(e) **Effect of interaction of fertilizer levels and manurial forms on dry weight of soybean (g/plant) at 75 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	16.34	26.91	31.57	24.94	13.23	24.17	23.22	20.21
F_1	30.76	32.28	43.48	35.51	22.51	30.00	33.00	28.50
F_2	35.90	38.12	40.35	38.12	23.17	30.53	35.44	29.71
Mean	27.67	32.44	38.47		19.64	28.23	30.55	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.99	10.02			3.31	6.65	

During the 1st year at 75 DAS the treatment combination 33% RDF and FC + PM recorded the highest values. The 100% RDF alone, with FC + PM and with FC + VC were statstically at par [Table 4.01.1(e)]. All other treatments were statistically superior over control.

At 75 DAS during the 2nd year 100% RDF with FC + PM combination showed maximum dry weight values and was statistically significant. The treatments 33% RDF with FC + PM and with FC + VC and 100% RDF alone were at par. All other treatments recorded significantly higher values over control

Table 4.01.1(f) **Effect of interaction of fertilizer levels and manurial forms on dry weight of soybean (g/plant) at 90 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	24.14	33.82	46.69	34.88	18.52	29.21	32.81	26.85
F_1	50.23	51.43	63.44	55.03	29.05	43.44	46.84	39.78
F_2	58.45	68.34	71.60	66.13	41.46	58.81	59.51	53.26
Mean	44.27	51.20	60.58		29.68	43.82	46.39	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.26	8.55			4.23	8.50	

At 90 DAS in the 1st year the highest value was observed in treatment 100% RDF with FC+PM [Table 4.01.1(f)]. Statistically comparable values were recorded by treatments 100% RDF with FC + VC and 33% RDF with FC + PM. Treatments 100% RDF alone, 33% RDF alone and with FC + VC belonged to the next best category and were superior over control.

In the 2nd year 100% RDF with FC + PM and with FC + VC were statistically superior over all the other treatments. However, treatments 33% RDF with FC + PM and with FC + VC, and 100% RDF alone were statistically the next best. All other treatments were significantly better than control.

4.1.1.5. Interaction effect of ferilizer levels and biofertilizer &/or organic spray

Table 4.01.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of soybean (g/plant) at 15 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.166	0.194	0.219	0.193	0.434	0.477	0.426	0.446
F_1	0.217	0.232	0.227	0.225	0.538	0.524	0.496	0.519
F_2	0.220	0.251	0.257	0.243	0.543	0.557	0.548	0.549
Mean	0.201	0.226	0.234		0.505	0.519	0.490	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.023	0.047			0.039	0.078	

At 15 DAS during the 1st year 100% RDF with PSB + CU treatment significantly influenced the dry weight [Table 4.01.2(a)]. Treatments 100% RDF alone and with PSB + Rhz, 33% RDF alone and with PSB + Rhz and with PSB + CU and PSB + CU were statistically at par with 100% RDF + PSB + CU.

During the 2nd year at 15 DAS there was significant difference in dry weight values. The 100% RDF and PSB + Rhz combination registered highest figures. Statistically comparable results were obtained in 100% RDF alone and with PSB + CU, 33% RDF alone with PSB + CU and with PSB + Rhz.

Table 4.01.2(b) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of soybean (g/plant) at 30 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.93	1.08	1.13	1.05	0.69	0.95	0.91	0.85
F_1	0.92	1.11	1.28	1.10	0.89	1.14	0.99	1.01
F_2	1.26	1.22	1.52	1.33	1.28	1.16	1.17	1.20
Mean	1.04	1.14	1.31		0.95	1.09	1.03	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.18	0.37			0.15	0.31	

At 30 DAS during 1st year the maximum values were obtained in by 100% RDF with PSB + CU [Table 4.01.2(b)]. Statistically comparable figures were recorded in treatments 33% RDF with PSB + CU, 100% RDF alone and with PSB + Rhz.

At 30 DAS during 2nd year 100% RDF alone had a pronounced effect on dry weight. Treatments 100% RDF with PSB + CU and with PSB + Rhz, 33% RDF with PSB + CU were statistically comparable.

Table 4.01.2(c) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of soybean (g/plant) at 45 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	2.73	1.88	3.98	2.86	1.83	2.59	2.73	2.38
F_1	4.12	3.37	3.73	3.74	3.17	3.16	3.39	3.24
F_2	4.89	4.31	5.68	4.96	4.09	3.48	5.07	4.21
Mean	3.91	3.19	4.46		3.03	3.07	3.73	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		1.05	2.11			0.71	1.43	

At 45 DAS during the 1st year maximum dry weight was obtained in 100% RDF with PSB+CU and was significantly higher over 33% RDF with PSB+Rhz combination

[Table 4.01.2(c)]. The treatments 100% RDF alone and with PSB+Rhz, PSB+CU alone and with 33% RDF were at par.

It was observed in the 2nd year at 45 DAS stage that 100% RDF with PSB+CU combination had a significantly pronounced dry weight value over all treatments except 100% RDF alone. However, all other treatments had significantly higher figures over control plot.

Table 4.01.2(d) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of soybean (g/plant) at 60 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	14.44	17.38	13.91	15.24	8.42	8.66	9.39	8.82
F_1	17.84	17.93	15.87	17.21	11.41	11.02	11.46	11.30
F_2	22.16	26.58	23.43	24.06	15.53	15.60	18.05	16.39
Mean	18.15	20.63	17.74		11.79	11.76	12.97	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		3.77	7.56			2.52	5.06	

At 60 DAS during the 1st year the 100% RDF with PSB+Rhz combination recorded the maximum values of dry weight and was significant over 33% RDF with PSB+Rhz combination [Table 4.01.2(d)]. The treatments 100% RDF alone and with PSB+CU were found to be comparable.

In the 2nd year at 60 DAS 100% RDF with PSB+CU recorded the highest value and was significant over treatment 33% RDF with PSB+CU. The treatments 100% RDF alone and with PSB+Rhz were at par.

Table 4.01.2(e) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of soybean (g/plant) at 75 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	25.97	21.55	27.30	24.94	17.89	18.94	23.79	20.21
F_1	28.10	37.21	41.21	35.51	26.62	28.33	30.56	28.50
F_2	35.52	37.05	41.80	38.12	22.84	34.11	32.20	29.72
Mean	29.86	31.94	36.77		22.45	27.13	28.85	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		4.99	10.02			3.31	6.65	

In the first year at 75 DAS 100% RDF with PSB+CU combination was significantly effective in obtaining high dry weight values over 33% RDF [Table 4.01.2(e)]. However, treatments 33% RDF with PSB+CUand with PSB+Rhz, 100% RDF alone and with PSB+Rhz were statistically at par.

During the 2nd year 100% RDF with PSB+Rhz combination recorded perceptibly high dry weight values than 33% RDF alone. Treatments 100% RDF with PSB+CU, 33% RDF with PSB+CU and with PSB+Rhz were statistically comparable. All other treatments except PSB+Rhz alone recorded significantly higher values over control.

Table 4.01.2(f) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of soybean (g/plant) at 90 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	31.01	36.39	37.24	34.88	23.06	26.60	30.88	26.85
F_1	48.70	56.88	59.53	55.04	36.86	40.11	42.38	39.78
F_2	62.29	71.24	64.86	66.13	50.08	55.70	53.99	53.26
Mean	47.33	54.84	53.88		36.67	40.80	42.42	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		4.26	8.55			4.23	8.50	

At 90 DAS in the 1st year the maximum dry weight was obtained in 100% RDF with PSB+Rhz followed by 100% RDF with PSB+CU which were statistically significant over 100% RDF alone [Table 4.01.2(f)]. However, treatments 33% RDF with PSB+CU and with PSB+Rhz were at par with 100% RDF alone. Again 33% RDF alone was statistically better than control.

In the 2nd year 100% RDF with PSB+Rhz was significantly effective above 33% RDF with PSB+CU, which in turn recorded higher values than control. Treatments 33% with PSB+CU and with PSB+Rhz were statistically comparable with 33% RDF with PSB+CU.

4.1.1.6 Interaction effect of forms of manures and biofertilizer and/or organic spray

Table 4.01.3(a) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of soybean (g/plant) at 15 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.164	0.229	0.272	0.222	0.503	0.528	0.498	0.510
C_1	0.207	0.237	0.212	0.219	0.477	0.500	0.478	0.485
C_2	0.231	0.212	0.218	0.220	0.536	0.530	0.493	0.520
Mean	0.201	0.226	0.234		0.505	0.519	0.490	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		0.023	0.047			0.039	0.078	

In the 1st year at 15 DAS PSB+CU alone recorded maximum dry weight and was significantly above FC+PM with PSB+CU combination [Table 4.01.3(a)].

However, FC+VC with PSB+Rhz, FC+PM alone, PSB+Rhz alone were at par. All other treatments were statistically above control.

During the 2nd year there was no significant difference because of the interaction effect between forms of manure and biofertilizer and/or organic spray. However, treatment FC+PM alone recorded the highest dry weight value and PSB+Rhz alone and with FC+PM followed closely.

Table 4.01.3(b) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of soybean (g/plant) at 30 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.89	1.24	1.27	1.13	0.91	1.01	1.13	1.02
C_1	1.01	1.22	1.47	1.24	0.94	1.24	0.91	1.03
C_2	1.21	0.96	1.18	1.12	1.01	1.00	1.03	1.01
Mean	1.04	1.14	1.31		0.95	1.09	1.03	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		0.18	0.37			0.15	0.31	

At 30 DAS during the 1st year FC+VC with PSB+CU combination was significant in producing the maximum dry weight over FC+VC alone [Table 4.01.3(b)]. However, treatments PSB+CU, PSB+Rhz, FC+VC with PSB+CU, FC+PM alone and with PSB+CU were statistically comparable.

During the 2nd year there was significant difference between the treatment with regard to interaction. FC+VC with PSB+ Rhz showed the highest figures. Treatments PSB+CU, FC+PM alone and with PSB+CU, PSB+Rhz, and FC+PM with PSB+Rhz were statistically comparable.

Table 4.01.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of soybean (g/plant) at 45 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	3.17	3.81	4.50	3.82	3.19	2.70	4.03	3.30
C_1	3.98	2.60	3.71	3.43	2.97	3.43	2.90	3.10
C_2	4.59	3.16	5.18	4.31	2.93	3.10	4.26	3.43
Mean	3.91	3.19	4.46		3.03	3.07	3.73	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		1.05	2.11			0.71	1.43	

At 45 DAS during the 1st year FC+PM with PSB+CU combination recorded maximum dry weight and was significant over control [Table 4.01.3(c)]. All other

treatments were statistically at par with this combination. In the 2nd year exactly similar trend was observed.

Table 4.01.3(d) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of soybean (g/plant) at 60 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	16.98	17.25	19.55	17.93	10.83	11.77	12.25	11.62
C_1	18.00	21.56	17.68	19.08	12.14	12.10	14.19	12.81
C_2	19.47	23.09	15.98	19.51	12.40	11.41	12.46	12.09
Mean	18.15	20.63	17.74		11.79	11.76	12.97	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		3.77	7.56			2.52	5.06	

At 60 DAS during the 1st year there was no significant difference between the interaction effect among treatments [Table 4.01.3(d)]. However, the maximum weight was obtained in FC+PM with PSB+Rhz followed by FC+VC with PSB+Rhz.

Similarly, in the 2nd year there was no statistically significant difference between the interaction effects among the treatments. However, PSB+CU withFC+PM recorded the maximum weight.

Table 4.01.3(e) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of soybean (g/plant) at 75 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	19.13	33.87	30.01	27.67	14.04	22.11	22.76	19.64
C_1	31.91	29.11	36.29	32.44	23.98	28.28	32.44	28.23
C_2	38.55	32.83	44.01	38.46	29.33	31.00	31.33	30.55
	29.86	31.94	36.77		22.45	27.13	28.84	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.99	10.02			3.31	6.65	

At 75 DAS during the 1st year it was perceptible that FC+PM with PSB+CU combination was significantly effective over PSB+Rhz alone [Table 4.01.3(e)]. Treatments FC+PM alone, FC+VC with PSB+CU were statistically comparable.

At 75 DAS during 2nd year the treatment combination FC+VC with PSB+CU was significantly superior to FC+VC alone. Treatments FC+PM alone, with PSB+Rhz and with PSB+CU and FC+VC with PSB+Rhz were at par with FC+VC with PSB+CU combination.

Table 4.01.3(f) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of soybean (g/plant) at 90 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	32.57	54.81	45.44	44.27	25.99	31.47	31.58	29.68
C_1	49.70	49.66	54.23	51.20	38.74	44.49	48.24	43.82
C_2	59.73	60.04	61.96	60.58	45.28	46.44	47.44	46.39
Mean	47.33	54.84	53.88		36.67	40.80	42.42	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.26	8.55			4.23	8.50	

During the 1st year at 90 DAS there was significant difference in the interaction effect between treatment combinations and FC+PM with PSB+CU was markedly above FC+VC alone [Table 4.01.3(f)]. The treatments FC+PM alone and with PSB+Rhz, PSB+Rhz alone and FC+VC with PSB+CU were statistically comparable with FC+PM with PSB+CU combination. The rest of the treatments were significantly superior to control.

During the 2nd year treatment FC+VC with PSB+CU was significantly above FC+VC alone. However, FC+PM with PSB+CU and with PSB+Rhz and FC+VC with PSB+Rhz combinations were comparable with FC+VC with PSB+CU. The rest of the treatments were above par over the control.

4.1.2 Root Nodulation

4.1.2.1 Fertilizer levels

Significant effect on nodulation due to fertilizer levels was obtained only in the second year at 60 and 75 DAS wherein the 33% RDF gave highest values (Table 4.02). At 60 DAS the plots with 0 application was at par. Further, it was observed that the maximum number of nodules per plant were invariably in plots with 33% RDF.

4.1.2.2 Manurial forms

The statistically significant effect on nodulation due to the difference in manurial forms was observed (Table 4.02) only at 60 DAS.However, highest values were generally recorded in plots treated with manure.

4.1.2.3 Biofertilizer and/or organic spray

There was significant difference between the treatments on the nodulation pattern of soybean in both the experimental years (Table 4.02). During the 1st year,

maximum number of nodules were recorded in successive stages of 15, 30, 45, and 60 DAS in plots inoculated with Rhizobium culture. Statistically par values were observed at 30, 45, and 60 DAS in plots with PSB+CU treatment. During the 2nd year, plots inoculated with Rhizobium recorded statistically significant nodule counts at 30, 45, 60, and 75 DAS.

Table 4.02 Effect of INM on nodulation of soybean (number /plant) during 1997-98 and 1998-99

Factors	15DAS		30DAS		45DAS		60 DAS		75 DAS
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1998-99
Levels of Fertilizers (F):									
F_0	4.06	7.70	5.67	12.24	7.94	11.87	15.73	19.47	19.23
F_1	6.87	9.17	4.52	11.21	5.96	14.97	26.74	20.89	28.55
F_2	3.97	7.86	3.47	10.41	2.62	13.08	14.06	13.84	17.70
	NS	NS	NS	NS	NS	NS	NS	*	*
Forms of manure (C):									
C_0	6.99	8.37	5.93	10.15	5.31	12.90	14.62	11.44	18.42
C_1	5.83	7.50	3.94	11.81	8.03	13.12	21.00	21.21	25.17
C_2	2.07	8.85	3.80	11.90	3.19	13.91	20.91	21.21	21.90
	NS	NS	NS	NS	NS	NS	NS	*	NS
Biofertilizers and/or organic spray (B):									
B_0	2.99	7.76	1.64	8.50	0.75	6.88	9.12	8.47	12.00
B_1	9.68	8.21	7.92	13.20	10.84	22.55	30.98	16.70	32.16
B_2	2.22	8.76	4.12	12.16	4.94	10.49	16.42	28.92	21.33
	*	NS	*	*	*	*	*	*	*
SEd ±	3.116	1.071	2.171	1.732	2.979	2.445	6.743	2.245	3.563
CD (0.05)	6.254	-	4.356	3.476	5.977	6.033	13.531	4.506	7.151
FxC FxB CxB:									
SEd ±	5.398	1.855	3.761	3.001	5.160	4.236	11.680	3.890	6.173
CD (0.05)	10.833	3.722	7.548	6.023	10.356	8.501	23.441	7.807	12.38

*Significant at P = 0.05 NS = non-significant

4.1.2.4 Interaction effect due to fertilizer levels and manurial forms

Table 4.02.1(a) Effect of interaction of fertilizer levels and manurial forms on root nodule count of soybean (number/plant) at 15 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	3.48	5.63	3.07	4.06	6.52	7.33	9.25	7.70
F_1	15.44	2.92	2.26	6.87	10.15	8.11	9.25	9.17
F_2	2.07	8.96	0.89	3.97	8.46	7.07	8.07	7.87
Mean	7.00	5.84	2.07		8.38	7.50	8.86	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		5.40	10.83			1.86	3.72	

At 15DAS during the 1st year 33% RDF alone recorded highly significant nodule count (15.44) over the control [Table 4.02.1(a)]. Treatments FC+VC alone and with 100% RDF obtained statistically comparable figures. The minimum mean number of nodules per plant (0.89) was observed in 100% RDF with FC+PM combination.

There was no significant difference in the 2nd year because of the interaction between the different treatment combinations. However, 33% RDF had the maximum count value (10.15).

Table 4.02.1(b) **Effect of interaction of fertilizer levels and manurial forms on root nodule count of soybean (number/plant) at 30 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	6.67	7.40	2.96	5.68	7.96	15.85	12.92	12.24
F_1	8.29	1.96	3.33	4.53	8.07	13.18	12.37	11.21
F_2	2.85	2.48	5.11	3.48	9.48	10.55	11.18	10.40
Mean	5.94	3.95	3.80		8.50	13.19	12.16	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		3.76	7.55			3.00	6.02	

The data obtained on nodule count did not show any statistically significant difference between the treatments [Table 4.02.1(b)]. However, the highest value (8.29) was obtained in the 33% RDF treatment.

In the 2nd year FC+VC treatment showed higher nodule count and was significantly better over 100% RDF treatment. Treatments 33% RDF with FC+VC and with FC+PM, 100% RDF with FC+PM and with FC+VC and FC+PM treatments were statistically comparable.

Table 4.02.1(c) **Effect of interaction of fertilizer levels and manurial forms on root nodule count of soybean (number/plant) at 45 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	4.92	15.07	3.85	7.95	10.55	10.92	14.15	11.87
F_1	9.24	5.70	2.96	5.97	12.33	15.44	17.14	14.97
F_2	1.78	3.33	2.77	2.63	15.81	13.00	10.44	13.08
Mean	5.31	8.03	3.19		12.90	13.12	13.91	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		5.16	10.36			4.24	8.50	

At 45 DAS during the 1st year FC+VC significantly effected the nodule count overFC+PM [Table 4.02.1(c)]. However, 33% RDF alone and with FC+VC and control plots were statistically at par with FC+VC.

In the 2nd year there was no significant interaction difference between the treatment combinations. However, 33% RDF with FC+PM marked the highest nodule count value (17.14).

Table 4.02.1(d) **Effect of interaction of fertilizer levels and manurial forms on root nodule count of soybean (number/plant) at 60 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	7.63	15.26	24.29	15.73	11.11	19.37	27.92	19.47
F_1	30.70	36.89	12.63	26.74	16.15	25.00	21.51	20.89
F_2	5.52	10.85	25.81	14.06	7.07	20.26	14.18	13.84
Mean	14.61	21.00	20.91		11.44	21.54	21.20	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		11.68	23.44			3.89	7.81	

At 60 DAS 33% RDF with FC+VC was significantly effective over treatment 33% RDF with FC+PM [Table 4.02.1(d)]. However, 33% RDF alone, FC+PM alone and with 100% RDF and FC+VC alone were statistically at par with 33% RDF with FC+VC.

In the 2nd year FC+PM registered a significantly higher nodule count per plant over FC+VC. However, treatments 33% RDF with FC+VC and with FC+PM and 100% RDF with FC+VC were statistically comparable with FC+PM. Further, the treatments 100% RDF with FC+PM and 33% RDF were at par with FC+VC combination.

Table 4.02.1(e) Effect of interaction of fertilizer levels and manurial forms on root nodule count of soybean (number/plant) at 75 DAS

Factors	1998-99			
	C_0	C_1	C_2	Mean
F_0	12.51	20.22	24.96	19.23
F_1	22.15	35.85	27.66	28.55
F_2	20.59	19.44	13.07	17.70
Mean	18.42	25.17	21.90	
		SEd ±	CD(0.05)	
		6.17	12.39	

In the 2nd year at 75 DAS 33% RDF with FC+VC combination produced highly significant nodule count/plant [Table 4.02.1(e)]. The treatments with FC+PM alone and with 33% RDF were on par.

4.1.2.5 Interaction between fertilizer levels and biofertilizer and/or organic spray

At 15 DAS in the 1st year maximum number of nodules/plant was obtained in treatment 33% RDF with PSB+Rhz which was significant over PSB+CU treatment [Table 4.02.2(a)]. All other treatment combinations were at par.

Table 4.02.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on root nodule count of soybean (number/plant) at 15 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	3.33	7.41	1.44	4.06	6.89	8.44	7.77	7.70
F_1	4.74	13.03	2.85	6.87	8.22	10.00	9.29	9.17
F_2	0.92	8.63	2.37	3.97	8.18	6.20	9.22	7.87
Mean	3.00	9.69	2.22		7.76	8.21	8.76	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		5.40	10.83			1.86	3.72	

In the 2nd year also the treatment combination 33% RDF with PSB+Rhz produced significant number of nodules per plant over 100% RDF with PSB+Rhz. All other treatments including the control were comparable.

Table 4.02.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on root nodule count of soybean (number/plant) at 30 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.33	13.52	3.18	5.68	8.25	13.07	15.40	12.24
F_1	4.18	6.48	2.92	4.53	12.15	12.66	8.81	11.21
F_2	0.41	3.77	6.26	3.48	10.04	9.70	11.48	10.41
Mean	1.64	7.92	4.12		10.15	11.81	11.90	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		3.76	7.55			3.00	6.02	

At 30 DAS in the 1st year the PSB+Rhz alone was significantly effective in per plant nodule count over the treatment 33% RDF [Table 4.02.2(b)]. Treatment combinations 33% RDF with PSB+Rhz and 100% RDF with PSB+CU were on par with PSB+Rhz and were significantly superior over all other treatments and control.

During the 2nd year, however, treatments PSB+CU recorded the highest value (15.40) followed closely by PSB+Rhz (13.07) both of which were significantly above treatment 33% RDF with PSB+CU and control. All other treatment combinations were at par with the effective treatments.

Table 4.02.2(c) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on root nodule count of soybean (number/plant) at 45 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	1.29	12.07	10.48	7.95	4.59	21.85	9.18	11.87
F_1	0.55	14.16	3.18	5.97	9.81	21.18	13.92	14.97
F_2	0.41	6.29	1.18	2.63	6.26	24.63	8.37	13.08
Mean	0.75	10.84	4.95		6.89	22.55	10.49	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		5.16	10.36			4.24	8.50	

At 45 DAS during the 1st year the treatment combination 33% with PSB+Rhz registered the maximum per plant nodule count and was significant over control [Table 4.02.2(c)]. Treatments PSB+Rhz, PSB+CU, and 100% RDF with PSB+Rhz were statistically at par with the treatment with maximum values.

In the 2nd year, however, 100% RDF with PSB+Rhz registered the highest per plant nodule count (24.63) followed closely by treatments PSB+Rhz alone and with 33% RDF, all of them were statistically superior to 33% RDF with PSB+CU combination, which in turn was significant over control. The treatments 33% alone, PSB+CU alone and with 100% RDF, and 100% RDF alone were at par with 33% RDF with PSB+CU combination.

Table 4.02.2(d) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on root nodule count of soybean (number/plant) at 60 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	5.26	31.74	10.18	15.73	5.70	30.07	22.63	19.47
F_1	14.11	44.11	22.00	26.74	12.63	29.96	20.07	20.89
F_2	8.00	17.11	17.07	14.06	7.11	26.74	7.66	13.84
Mean	9.12	30.99	16.42		8.48	28.92	16.79	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		11.68	23.44			3.89	7.81	

In the 1st year at 60 DAS 33% RDF with PSB+Rhz produced the highest (44.11) per plant nodule count, followed by PSB+Rhz alone (31.74) and 33% RDF with PSB+CU (22.00), and all of these were significantly superior over control as well as other treatment combinations [Table 4.02.2(d)].

During the 2nd year PSB+Rhz obtained maximum (30.07) values followed closely by treatment combinations PSB+Rhz with 33% (29.96) and with 100% (26.74) RDF and PSB+CU. These were significant over treatment combination 33% RDF with PSB+CU, which in turn was superior over control and treatments 100% RDF alone and with PSB+CU. Treatment 33% RDF alone was comparable with 33% RDF with PSB+CU.

During the 2nd year at 75 DAS 33% RDF with PSB+Rhz registered maximum (41.11) followed by PSB+Rhz alone (34.48) [Table 4.02.2(e)]. These were significantly superior over treatment 33% RDF with PSB+CU combination. Treatments 100% RDF

with PSB+Rhz and with PSB+CU, 33% RDF alone and PSB+CU were at par with 33% with PSB+CU.

Table 4.02.2(c) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on root nodule count of soybean (number/plant) at 75 DAS

Factors	1998-99			
	B_0	B_1	B_2	Mean
F_0	5.66	34.48	17.55	19.23
F_1	18.66	41.11	25.89	28.55
F_2	11.66	20.89	20.55	17.70
Mean	11.99	32.16	21.33	
		SEd ±	CD(0.05)	
		6.17	12.39	

4.1.2.6 Interaction effect of manurial forms and biofertilizers and/or organic spray

Table 4.02.3(a) Effect of interaction of manurial forms and biofertilizer and/or organic spray on root nodule count of soybean (number/plant) at 15 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	5.18	13.89	1.92	7.00	5.37	9.53	10.22	8.37
C_1	2.00	12.15	3.37	5.84	8.40	6.96	7.15	7.50
C_2	1.81	3.03	1.37	2.07	9.51	8.14	8.92	8.86
Mean	3.00	9.69	2.22		7.76	8.21	8.76	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		5.40	10.83			1.86	3.72	

At 15 DAS during the 1st year the treatment PSB+Rhz recorded maximum per plant nodule count which was significantly higher over treatment FC+PM with PSB+Rhz combination [Table 4.02.3(a)]. Treatments FC+VC with PSB+Rhz and with PSB+CU were at par with PSB+Rhz.

During the 2nd year there was significant difference between the treatments and control. Treatment PSB+CU registered the highest value followed closely by treatment PSB+Rhz. All treatments were on par.

Table 4.02.3(b) Effect of interaction of manurial forms and biofertilizer and/or organic spray on root nodule count of soybean (number/plant) at 30 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	3.44	11.18	3.18	5.93	5.88	9.55	10.07	8.50
C_1	0.55	8.40	2.89	3.95	13.04	11.55	15.00	13.20
C_2	0.92	4.18	6.29	3.80	11.52	14.33	10.62	12.16
Mean	1.64	7.92	4.12		10.15	11.81	11.90	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		3.76	7.55			3.00	6.02	

At 30 DAS during the 1st year the PSB+Rhz treatment showed the highest per plant nodule count [Table 4.02.3(b)]. Treatment combinations FC+VC with PSB+Rhz, FC+PM with PSB+CU and with PSB+Rhz were statistically comparable.

During the 2nd year the treatment combination FC+VC with PSB+CU secured maximum nodules per plant and all other combinations were comparable and significantly above control.

Table 4.02.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on root nodule count of soybean (number/plant) at 45 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.37	12.02	3.55	5.31	4.18	23.33	11.18	12.90
C_1	1.00	13.62	9.48	8.03	8.22	21.37	9.77	13.12
C_2	0.89	6.88	1.81	3.19	8.26	22.96	10.52	13.91
Mean	0.75	10.84	4.95		6.89	22.55	10.49	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		5.16	10.36			4.24	8.50	

At 45 DAS during the 1st year treatment combination FC+VC with PSB+Rhz showed significantly higher number of nodules/plant over treatment combination FC+PM with PSB+CU [Table 4.02.3(c)]. Treatment combinations PSB+Rhz alone and with FC+PM, PSB+CU alone and with FC+VC were statistically comparable with the treatment with the highest value.

During the 2nd year PSB+Rhz registered the maximum per plant nodule count (23.33) followed by treatment combinations PSB+Rhz with FC+PM (22.96) and with FC+VC (21.37). These were on par and statistically superior over other treatments and control.

Table 4.02.3(d) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on root nodule count of soybean (number/plant) at 60 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	3.89	29.33	10.63	14.62	3.85	15.89	14.59	11.44
C_1	13.81	30.48	18.70	21.00	9.63	36.81	18.18	21.54
C_2	9.66	33.14	19.92	20.91	11.96	34.07	17.59	21.21
Mean	9.12	30.98	16.42		8.48	28.92	16.79	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		11.68	23.44			3.89	7.81	

At 60 DAS in the 1st year the treatment combination FC+PM with PSB+Rhz significantly effected the nodulation pattern over FC+PM alone and control [Table

4.02.3(d)]. All other treatment combinations were at par with the most effective treatment.

During the 2nd year the treatment combination FC+VC with PSB+Rhz was significantly better over FC+VC with PSB+CU.Treatment FC+PM with PSB+Rhz was comparable. However, all other treatment combinations, except FC+VC alone and control, were at par with FC+VC with PSB+CU.

Table 4.02.3(e) Effect of interaction of manurial forms and biofertilizer and/or organic spray on root nodule count of soybean (number/plant) at 75 DAS

Factors	1998-99			
	B_0	B_1	B_2	Mean
C_0	4.41	29.18	21.66	18.42
C_1	16.63	35.48	23.41	25.17
C_2	14.96	31.81	18.92	21.90
Mean	12.00	32.16	21.33	
		SEd ±	CD(0.05)	
		6.17	12.39	

There was significant difference between all the treatment combinations and control with regard to nodulation at 75 DAS during the 2nd year [Table 4.02.3(e)]. All treatment combinations were on par.

4.1.3 Yield and yield attributes

4.1.3.1.Fertilizer levels

The number of pods per plant in both the years (Table 4.03) was significantly different as effected by the different levels of fertilizers. The treatment with 100% RDF registered higher number (93,92 and 81.76 respectively in the 1st and 2nd years) over the treatment 33%, which in turn was significantly higher (63.15 and 55.41 respectively in the 1st and 2nd years) over 0 level (47.29 and 36,64 respectively in the 1st and 2nd years).

The test weight values in the 1st year were significantly affected as a result of different levels of fertilizer. The treatment combination with 100% RDF recorded maximum (90.88 g), followed by 33% RDF which was on par with the 100% RDF combination. In the 2nd year statistically there was no difference between the different levels. However, combinations with 33% RDF resulted in maximum test weight (65.08 g) and, the minimum values were obtained in combinations with 0 levels (62.57 g).

The soybean yield in both the years were signifcantly influenced by the difference in the treatment combinations. The treatment combinations with 100% RDF

produced highest yield (2849.00 and 2478.00 kg ha^{-1} respectively in 1^{st} and 2^{nd} years), followed by combinations with 33% RDF (2118.00 and 1846.00 kg ha^{-1} respectively in 1^{st} and 2^{nd} years) which in turn were significantly higher than the 0 level combinations (1504.00 and 1373.00 kg ha^{-1} respectively in the 1^{st} and 2^{nd} years).

A similar trend was observed in the biological yield during 2^{nd} year. The treatment combination with 100% RDF registered 5425.00 kg ha^{-1} which was significantly above treatment combination with 33% RDF (3804.00 kg ha^{-1}), which again was significantly superior to 0 level combinations (2674.00 kg ha^{-1}).

The treatment of 33% RDF registered significantly higher values of carbohydrate and oil content (51.46 and 16.14% respectively) in seed over treatment 100% RDF (49.57 and 15.43% respectively), which in turn was superior to 0 level (48.05 and 15.42% respectively). However, the highest protein content was obtained in treatment 100% RDF, which was significantly above the 33% RDF, which in turn was superior to the 0 level (5.73, 5.66 and 5.62% respectively).

4.1.3.2 Manurial forms

Significant difference was obtained during both the years in terms of number of pods per plant as a result of different forms of manure (Table 4.03). The FC+PM combination registered maximum values (76.97 and 69.30 respectively in the 1^{st} and 2^{nd} years) and was followed by treatment combinations FC+VC (68.65 and 54.49 respectively in the 1^{st} and 2^{nd} year). However, in the 2^{nd} year there was no significant difference between FC+VC and 0 forms of manure.

Test weight values were significantly uneffected as a result of different manurial forms. Neverthless, the higher values were registered by FC+PM and FC+VC combinations.

The seed yield was highly significant in both the years. The highest yield was obtained by FC+PM combination (2350.00 and 2100 kg ha^{-1} respectively in the 1^{st} and 2^{nd} year) followed by FC+VC combination (2280.00 and 1936.00 kg ha^{-1}) which was on par.

The biological yield in the 2^{nd} year was 4604.00 kg ha^{-1} in treatment combination with FC+PM and was significant above other forms.

Table 4.03 **Effect of INM on economic and biological yield, carbohydarate, protein and oil content of soybean during 1997-98 and 1998-99**

Factors	Pods/plant		Test weight (g)		Seed yield (kg ha^{-1})		Biological yield (kg ha^{-1})	Carbohydrate in seed (%)	Protein in seed (%)	Oil in seed (%)
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1998-99	1998-99	1998-99	1998-99
Fertilizer levels (F):										
F_0	47.29	36.64	80.21	62.57	1504.00	1373.00	2647.00	48.05	5.66	15.42
F_1	63.15	55.41	85.46	65.08	2118.00	1846.00	3804.00	51.46	5.62	16.14
F_2	93.92	81.76	90.88	64.43	2849.00	2478.00	5425.00	49.57	5.73	15.43
	*	*	*	NS	*	*	*	*	*	*
Forms of manure (C):										
C_0	58.74	50.02	82.84	63.38	1911.00	1661.00	3413.00	52.33	5.68	16.05
C_1	68.65	54.49	86.61	63.88	2210.00	1936.00	3859.00	49.25	5.54	15.09
C_2	76.97	69.30	87.11	64.81	2350.00	2100.00	4604.00	47.49	5.80	15.86
	*	*	NS	NS	*	*	*	*	*	*
Biofertilizer &/or organic spray (B):										
B_0	63.03	51.24	83.69	62.26	1976.00	1681.00	3709.00	52.05	5.70	15.51
B_1	70.08	58.43	86.73	65.07	2217.00	2003.00	4126.00	47.90	5.60	15.75
B_2	71.25	64.13	86.13	64.74	2278.00	2013.00	4041.00	49.13	5.72	15.73
	*	*	NS	NS	*	*	NS	*	*	*
SEd ±	3.050	3.490	2.708	1.422	84.20	85.00	245.44	0.0634	0.0046	0.0031
CD(0.05)	6.121	7.004	5.434	-	169.05	166.60	492.51	0.1273	0.0092	0.0062
FxC FxB CxB:										
SEd ±	5.284	6.046	4.691	2.463	145.90	143.90	425.1	0.1099	0.0080	0.0053
CD(0.05)	10.604	12.134	9.410	4.943	292.80	287.80	853.1	0.2205	0.0160	0.0107

*Significant at P = 0.05 NS = non-significant

The 0 level treatment recorded significantly higher amount of seed carbohydrate and oil (52.33 and 16.05% respectively) than treatments FC+VC and FC+PM (49.29 and 15.86% respectively). However, the treatment FC+PM registered significantly higher values of protein than the 0 level, which in turn showed higher figures than the treatment FC+VC (5.80, 5.68 and 5.47% respectively).

4.1.3.3 Biofertilizer and/or organic spray

The per plant pod count during both the experimental years were highly significant as a result of different combinations with this factor (Table 4.03). The maximum value was registered by PSB+CU (71.25 and 64.13 respectively in the 1^{st} and 2^{nd} years) followed by FC+VC combinations (70.08 and 58.43 respectively in the 1^{st} and 2^{nd} years) both of which were on par.

The test weight values were not significantly influenced by this factor. However, the maximum values (86.73 and 65.07 respectively) were recorded in PSB+Rhz combination, followed by PSB+CU combination (86.13 and 64.74 respectively) in the 1^{st} and 2^{nd} years respectively.

The seed yield was significantly higher in both the years in both the combinations. The values obtained by treatment PSB+CU combination were 2278.00 and 2013 kg ha^{-1} respectively in 1^{st} and 2^{nd} years and by the treatment combination PSB+Rhz were 2217.00 and 2003.00 kg ha^{-1} respectively in the 1^{st} and 2^{nd} years.

The biological yield though not statistically significant, was maximum in treatment combinations with PSB+Rhz followed by PSB+CU (4126.00 and 4041.00 kg ha^{-1} respectively) in the 2^{nd} year.

The 0 level combination produced highest value of carbohydrate content in seed (52.05%), which was significantly higher than the treatment PSB+CU (49.13%). However, the treatment PSB+CU registered significant higher values than treatment PSB+Rhz (47.90%).

The treatment PSB+CU registered significant and highest protein content (5.72%) and the treatment PSB+Rhz produced significant and highest oil content (15.75%) in seed.

4.1.3.4 Interaction effect between levels of fertilizer and manurial forms

In the 1st year the pod count per plant was significantly effected due to the interaction of fertilizer levels and manurial forms [Table 4.03.1(a)]. Treatment 100% RDF with FC+PM combination registered the maximum number (109.80) and was superior over treatment 100% RDF with FC+VC. Similarly, treatment 100% RDF with FC+VC was significantly better than 100% RDF alone. Again 100% RDF performed significantly better than 33% RDF with FC+PM combination. Treatments 33% RDF alone and with FC+VC combination was on par with 33% RDF with FC+PM and these were superior to combinations with 0 level fertilizer treatments. However, 0 level RDF with FC+PM and with FC+VC were above control.

Table 4.03.1(a) Effect of interaction of fertilizer levels and manurial forms on pod count of soybean (number/plant).

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	39.55	49.70	52.63	47.29	24.56	41.35	44.00	36.64
F_1	60.55	60.40	68.48	63.14	56.33	51.00	58.89	55.41
F_2	76.11	95.85	109.80	93.92	69.17	71.11	105.00	81.76
Mean	58.74	68.65	76.97		50.02	54.49	69.30	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		5.28	10.60			6.05	12.13	

A similar trend was observed in the 2nd year also, though the overall performance of the variety (PK-327) used in that year was lesser.

Table 4.03.1(b) Effect of interaction of fertilizer levels and manurial forms on test weight of soybean (g)

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	71.73	83.39	85.50	80.21	59.61	63.98	64.11	62.57
F_1	83.72	87.39	85.28	85.46	64.97	65.92	64.34	65.08
F_2	93.06	89.06	90.54	90.89	65.55	61.75	65.98	64.43
Mean	82.84	86.61	87.11		63.38	63.88	64.81	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.69	9.41			2.46	4.94	

During the 1st year the test weight values were significantly effected by interaction effect and the maximum figure (93.06) was obtained by treatment 100% RDF alone [Table 4.03.1(b)]. All other treatment combinations except FC+VC (83.39) alone were statistically par with treatment 100% RDF alone.

Almost similar trend was observed in the 2nd year except that the maximum values were recorded by treatment combination 100% RDF with FC+PM.

Table 4.03.1(c) Effect of interaction of fertilizer levels and manurial forms on seed yield of soybean (kg ha^{-1})

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	1124.00	1561.00	1827.00	1504.00	1019.00	1406.00	1695.00	1373.33
F_1	2004.00	2265.00	2085.00	2118.00	1725.00	1898.00	1914.00	1845.67
F_2	2605.00	2804.00	3139.00	2849.33	2240.00	2504.00	2691.00	2478.33
Mean	1911.00	2210.00	2350.33		1661.33	1936.00	2100.00	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		145.90	292.82			143.90	288.81	

The seed yield was significantly influenced as a result of different treatments in the 1st year [Table 4.03.1(c)]. Treatment 100% RDF with FC+PM combination yielded the highest productivity (3139.00 kg ha^{-1}) followed by 100% RDF with FC+VC and 100% RDF alone. The treatment combinations 33% RDF alone, with FC+VC and with FC+PM were comparable with each other and superior to FC+PM and FC+VC treatments.

In the 2nd year the seed yield was significantly effected as a result of interaction between fertilizer levels and manurial forms. The treatment combination 100% RDF with FC+PM registered the maximum (2691.00 kg ha^{-1}) followed by 100% RDF with FC+VC (2504.00 kg ha^{-1}). Further, it was observed that the 33% RDF with FC+PM produced (1914.00 kg ha^{-1}) significantly above treatment FC+VC (1406.00 kg ha^{-1}). However, treatments 33% RDF alone and with FC+VC, and FC+PM alone were comparable with treatment combination 33% RDF with FC+PM.

Table 4.03.1(d) Effect of interaction of fertilizer levels and manurial forms on biological yield of soybean (kg ha^{-1})

Factors	1998-99			
	C_0	C_1	C_2	Mean
F_0	1909.00	2896.00	3135.00	2646.67
F_1	3581.00	3919.00	3911.00	3803.67
F_2	4749.00	4761.00	6765.00	5425.00
Mean	3413.00	3858.67	4603.67	
		SEd ±	CD(0.05)	
		425.10	853.18	

In the 2nd year the biological yield was significantly influenced due to the interaction of levels of fertilizer and manurial forms [Table 4.03.1(d)]. Treatment 100% RDF with FC+PM combination registered the highest biological yield (6765.00 kg ha^{-1}) which was superior over all the other treatment combinations. The treatment combination 100% RDF with FC+VC was significantly better over treatment 33% RDF alone. However, treatments 100% RDF alone, 33% RDF with FC+VC and with FC+PM

were on par with the treatment combination. 100% RDF with FC+VC. Further, it was apparent that treatments FC+PM alone and FC+VC alone were significantly above control.

The interaction between fertilizer levels and manurial forms did not influence the carbohydrate content of soybean seed [Table 4.03.1(e)]. However, treatment 33% RDF was superior to treatment 100% RDF which in turn was better than treatment combination of 33% RDF with FC+VC (56.36, 51.13 and 50.56% respectively). This combination was superior to the control (49.50%).

Table 4.03.1(e) Effect of interaction of fertilizer levels and manurial forms on carbohydrate content (%) of soybean seeds

Factors	1998-99			
	C_0	C_1	C_2	Mean
F_0	49.50	47.45	47.22	48.06
F_1	56.36	50.56	47.46	51.46
F_2	51.13	49.77	47.80	49.57
Mean	52.33	49.26	47.49	
		SEd ±	CD(0.05)	
		0.110	0.221	

Table 4.03.1(f) Effect of interaction of fertilizer levels and manurial forms on content of protein and oil in seed of soybean (%) during 1998-99

Factors	Protein content in seed (%)				Oil content in seed (%)			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	5.66	5.41	5.93	5.67	15.43	13.81	17.03	15.42
F_1	5.65	5.67	5.57	5.63	17.14	15.39	15.89	16.14
F_2	5.74	5.56	5.90	5.73	15.57	16.06	14.66	15.43
Mean	5.68	5.55	5.80		16.05	15.09	15.86	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.008	0.016			0.0054	0.0108	

The maximum value of protein content in soybean [Table 4.03.1(f)] was registered in treatment FC+PM which was significantly above the treatment combination 100 % RDF with FC+PM, which in turn was superior to the treatment 100 % RDF alone (5.92, 5.90 and 5.74 % respectively).

The oil content was significantly higher in treatment 33% RDF alone over the treatment FC+PM, which was in turn superior to the treatment combination 100% RDF with FC+VC (17.14, 17.03 and 16.06 % respectively).

4.1.3.5 Interaction between fertilizer levels and biofertilizer and/or organic spray

Table 4.03.2(a) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on pod count of soybean (number/plant) at harvest.

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	39.26	52.44	50.18	47.29	30.39	38.91	40.61	36.64
F_1	63.33	62.18	63.92	63.14	52.22	57.17	56.83	55.41
F_2	86.52	95.61	99.63	93.92	71.11	79.22	94.94	81.76
Mean	63.04	70.08	71.24		51.24	58.43	64.13	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		5.28	10.60			6.05	12.13	

In the 1st year the pod count per plant was significantly effected as a result of interaction [Table 4.03.2(a)]. Treatment 100% RDF with PSB+CU yielded the highest value (99.63). The treatment 100% RDF with PSB+Rhz combination was on par with the former treatment. The 3rd best treatment was 100% RDF alone which was significantly superior to the rest of the treatments. The treatment combinations with 33% RDF were all on par and were significantly superior to the 0 level fertilizer combinations. Again the treatments PSB+Rhz and PSB+CU were superior to the control.

Almost similar trend was observed in the 2nd year with regard to per plant pod count as a result of interaction of fertilizer levels and biofertilizer and/or organic spray, except that the 0 level combinations were not significantly different over control.

Table 4.03.2(b) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on test weight (g) of soybean

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	75.81	83.09	81.72	80.21	60.62	64.75	62.33	62.57
F_1	84.00	86.22	86.17	85.46	62.85	67.09	65.28	65.07
F_2	91.26	90.89	90.50	90.88	63.31	63.35	66.62	64.43
Mean	83.69	86.73	86.13		62.26	65.06	64.74	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		4.69	9.41			2.46	4.94	

The test weight value was significantly effected due to the interaction of fertilizer and biofertilizer and/or organic spray [Table 4.03.2(b)]. The treatment 100% RDF alone registered the maximum value (91.26) and all other treatment combinations, except PSB+CU were statisticlly comparable with it.

Whereas, in the 2nd year the maximum value was produced by treatment combination 33% RDF with PSB+Rhz and all other treatments were at par with the former.

Table 4.03.2(c) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on seed yield (kg ha^{-1}) of soybean**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	1363.00	1487.00	1661.00	1503.67	1310.00	1324.00	1486.00	1373.33
F_1	2062.00	2203.00	2088.00	2117.67	1703.00	1976.00	1859.00	1846.00
F_2	2502.00	2961.00	3085.00	2849.33	2030.00	2709.00	2696.00	2478.33
Mean	1975.67	2217.00	2278.00		1681.00	2003.00	2013.67	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		145.90	292.82			143.90	288.81	

As a result of interaction seed yield was significantly different among the various treatment combinations [Table 4.03.2(c)]. The maximum yield was recorded by treatment combination 100% RDF with PSB+CU (3085.00 kg ha^{-1}) followed by 100% RDF with PSB+Rhz (2961.00 kg ha^{-1}), both of which were on par. The yield obtained from treatment combinations with 33% RDF ranged from 2062.00 to 2203.00 kg ha^{-1} which were statistically superior to 0 level fertilizer combinations. However, PSB+CU (1661.00 kg ha^{-1}) and PSB+Rhz (1487.00 kg ha^{-1}) were superior to control (1363.00 kg ha^{-1}).

Somewhat similar trend was observed during the 2nd year, except that the 100% RDF alone was comparable with 33% RDF combinations and the 0 level fertilizer combinations were not significant in their performance over control

Table 4.03.2(d) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on biological yield of soybean (kg ha^{-1})

Factors	1998-99			
	B_0	B_1	B_2	Mean
F_0	2455.00	2758.00	2727.00	2646.67
F_1	3296.00	4093.00	4022.00	3803.67
F_2	5375.00	5526.00	5375.00	5425.33
Mean	3708.67	4125.67	4041.33	
		SEd ±	CD(0.05)	
		425.10	853.18	

The biological yield in the 2nd year was influenced by the interaction between treatment combinations [Table 4.03.2(d)]. Treatment 100% RDF with PSB+Rhz registered the highest biological yield (5526.00 kg ha^{-1}) followed by 100% RDF alone (5375.00 kg ha^{-1}) and with PSB+CU (5375.00 kg ha^{-1}). All the three treatment

combinations with 33% RDF were on par with each other and were statistically better than combinations with 0 level fertilizer treatment. There was no significant difference between combinations with 0 level fertilizer and control.

Table 4.03.2(e) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on carbohydrate content (%) of soybean seeds

Factors	1998-99			
	B_0	B_1	B_2	Mean
F_0	51.93	47.97	44.26	48.05
F_1	51.07	47.04	56.26	51.46
F_2	53.16	48.68	46.86	49.57
Mean	52.05	47.90	49.13	
		SEd ±	CD(0.05)	
		0.110	0.221	

The interaction between fertilizer levels and biofertilizer showed significant influence on the carbohydrate level in the soybean seeds [Table 4.03.2(e)]. The treatment combination 33% RDF with PSB+CU registered the maximum figures followed by treatment 100% RDF, 0 level combination, 33% RDF and 100% RDF with PSB+Rhz combination (56.26, 53.16, 51.93, 51.07 and 48.68% respectively).

Table 4.03.2(f) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on content of protein and oil in seed (%) of soybean during 1998-99

Factors	Protein content in seed (%)				Oil content in seed (%)			
	B_0	B_1`	B_2	Mean	B_0	B_1	B_2	Mean
F_0	5.81	5.43	5.75	5.67	15.40	15.11	15.76	15.42
F_1	5.47	5.77	5.64	5.63	16.05	16.20	16.17	16.14
F_2	5.84	5.60	5.76	5.73	15.07	15.96	15.26	15.43
Mean	5.71	5.60	5.72		15.51	15.76	15.73	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.0080	0.0160			0.0054	0.0108	

The interaction affect of fertilizer levels and biofertilizer and/or organic spray was not apparent [Table 4.03.2(f)]. However, the maximum figures of protein content were recorded in treatment 100% RDF alone followed by the zero level combination, which in turn was superior to the treatment combination 33% RDF with PSB+Rhz (5.83, 5.81 and 5.77 % respectively). The treatment combination 100% RDF with PSB+CU (5.76%) was comparable with the treatment 33% RDF with PSB+Rhz.

The oil content in soybean was influenced by the interaction of fertilizer levels and biofertilizer and/or organic spray. The treatment combination 33% RDF with PSB+Rhz showed the maximum figures and was statistically superior to combination 33% RDF with PSB+CU, which in turn was superior to 33% RDF alone (16.20. 16.17 and 16.05 %)

4.1.3.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

Table 4.03.3(a) Effect of interaction of manurial forms and biofertilizer and/or organic spray on pod count of soybean (number/plant) at harvest

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	48.63	68.03	59.55	58.74	40.33	54.39	55.33	50.02
C_1	66.11	66.85	73.00	68.65	52.28	46.13	65.06	54.49
C_2	74.37	75.35	81.18	76.97	61.11	74.78	72.00	69.30
Mean	63.04	70.08	71.24		51.24	58.43	64.13	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		5.28	10.60			6.05	12.13	

The interaction effect due to manurial forms and biofertilizer and /or organic spray significantly influenced the per plant pod count [Table 4.03.3(a)]. The maximum value was recorded by FC+PM with PSB+CU combination, which was closely followad by FC+PM with PSB+Rhz, FC+PM alone, and FC+VC with PSB+CU, all of which were on par. The rest of the treatments were on par with each other and significantly superior to control.

In the 2nd year also, somewhat similar trend was observed, except that the FC+VC with PSB+CU was found to be on par with the most effective treatment. The rest of the treatment combinations were at par with each other and significantly superior over control.

Table 4.03.3(b) Effect of interaction of manurial forms and biofertilizer and/or organic spray on test weight (g) of soybean

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	77.76	84.48	86.28	82.84	60.07	64.85	65.21	63.38
C_1	85.00	87.06	87.78	86.61	62.49	63.95	65.21	63.88
C_2	88.32	88.67	84.33	87.11	64.22	66.39	63.82	64.81
Mean	83.69	86.74	86.13		62.26	65.06	64.75	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.69	9.41			2.46	4.94	

Test weight values from all treatments were [Table 4.03.3(b)] significantly different from control. The mean maximum value was recorded in treatment FC+VC with PSB+Rhz (88.67 g) combination and the minimum from control (77.76 g). All the other treatment combinations were statistically on par with the treatment with maximum value. Almost similar trend was observed in the 2nd year.

Table 4.03.3(c) Effect of interaction of manurial forms and biofertilizer and/or organic spray on seed yield (kg ha^{-1}) of soybean

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	1582.00	2025.00	2020.00	1875.67	1315.00	1817.00	1852.00	1661.33
C_1	1919.00	1798.00	1639.00	1785.33	1755.00	1998.00	2055.00	1936.00
C_2	1872.00	1890.00	2038.00	1933	1974.00	2194.00	2133.00	2100.33
Mean	1791.00	1904.33	1899.00		1681.33	2003.00	2013.33	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		145.90	292.80			143.90	288.81	

The seed yield was influenced as a result of interaction of manurial levels and biofertilizer and/or organic spray [Table 4.03.3(c)]. The maximum value was registered by FC+PM with PSB+CU (2038.00 kg ha^{-1}) which was significantly better over treatment combination FC+VC with PSB+CU (1639.00 kg ha^{-1}). All other combinations were at par with the treatment with maximum seed yield.

In the 2nd year the treatment combination FC+PM with PSB+Rhz recorded maximum seed yield (2194.00 kg ha^{-1}) which was significantly superior over PSB+CU alone. Treatment combinations FC+PM alone and with PSB+CU, FC+VC with PSB+CU and with PSB+Rhz were statistically comparable with FC+PM with PSB+Rhz treatment combination. However, the treatments PSB+Rhz alone and FC+VC alone were on par with PSB+CU alone.

Table 4.03.3(d) Effect of interaction of manurial forms and biofertilizer and/or organic spray on biological yield (kg ha^{-1}) of soybean

Factors	1998-99			
	B_0	B_1	B_2	Mean
C_0	2880.00	3556.00	3804.00	3413.33
C_1	3406.00	3725.00	4445.00	3858.67
C_2	4840.00	5095.00	3876.00	4603.67
Mean	3708.67	4125.33	4041.67	
		SEd $\pm$	CD(0.05)	
		425.10	853.18	

The biological yield was significantly [Table 4.03.3(d)] influenced by the interaction effect. The values ranged from 5095.00 to 2880.00 kg ha^{-1} (control). The maximum value was registered by FC+PM with PSB+Rhz (5095.00 kg ha^{-1}), which was significantly different from FC+PM with PSB+CU. The treatments FC+PM, and FC+VC with PSB+CU were statistically at par with the best treatment combination. All other treatment combinations were on par with each other and were significantly better than control.

Table 4.03.3(e) Effect of interaction of manurial forms and biofertilizer and/or organic spray on carbohydrate content (%) of soybean seeds

Factors	1998-99			
	B_0	B_1	B_2	Mean
C_0	58.25	49.84	48.90	52.33
C_1	49.49	47.72	50.57	49.26
C_2	48.42	46.14	47.91	47.49
Mean	52.05	47.90	49.13	
		SEd ±	CD(0.05)	
		0.110	0.221	

The interaction between manurial forms and biofertilizer and/or organic spray registered only the second highest figures of carbohydrate content [Table 4.03.3(e)] of soybean seed in treatment FC+VC with PSB+CU (50.57%), which was significantly superior to other treatments except the 0 level combination (58.25%).

Table 4.03.3(f) Effect of interaction of manurial forms and biofertilizer and/or organic spray on content of protein and oil in seed (%) of soybean during 1998-99

Factors	Protein content in seed (%)				Oil content in seed (%)			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	5.56	5.74	5.74	5.68	16.39	15.99	15.76	16.05
C_1	5.79	5.27	5.58	5.55	15.43	15.48	14.35	15.09
C_2	5.77	5.79	5.83	5.80	14.72	15.79	17.07	15.86
Mean	5.71	5.60	5.72		15.51	15.75	15.73	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.0080	0.0160			0.0054	0.0108	

The protein content was influenced by the interaction of manurial forms and biofertilizer and/or organic spray [Table 4.03.3(f)]. The treatment combination FC+PM with PSB+CU registered significantly higher values than treatment combination FC+PM with PSB+Rhz, which was in turn superior to treatment FC+PM alone (5.83, 5.79 and 5.76% respectively). Treatment FC+VC alone (5.79%) was statistically on par with the second best treatment, i.e., FC+PM with PSB+Rhz.

The oil content of soybean was significantly higher in treatment combination FC+PM with PSB+CU (17.07 %), which was superior to all other treatments.

4.1.4 Post-cropping status of soil

4.1.4.1 Fertilizer levels

Significant differences between treatments on the soil status (Table 4.04) after the harvest of soybean in the system was observed particularly during the 1st year. The pH and EC_{25} were significantly lower in the treatments with 33% RDF than treatments with

100% RDF, which in turn were significantly lower than combinations with 0 level RDF. The % organic carbon and available potassium were also signficantly higher in the treatment combinations with 33% RDF than the combinations with 100% RDF. However, the available phosphorus was on par in both 33% and 100% RDF and significantly higher than control.

In the 2nd year, only the % organic carbon was significantly influenced by the interaction effect and both the treatment combinations with 100% and 33% RDF were equally superior to 0 level RDF combinations.

4.1.4.1 Manurial forms

The post-cropping soil status (Table 4.04) as a result of manurial forms showed almost a similar trend, except the EC_{25} and % organic carbon during the 2nd year. The EC_{25} was significantly lower in treatment combinations with 33% and 100% RDF than with 0 level RDF combination. The % organic carbon was not significantly effected by any combination during both the years.

4.1.4.2 Biofertilizer and/or organic spray

Trends similar to those observed in the above factors were noticed in this 3rd factor, except that the available potassium values were on par in both the treatment combinations with 33% and 100% RDF (399.40 and 424.20 kg ha^{-1} respectively) and were significantly higher than control (Table 4.04). In the 2nd year the maximum and minimum value of available potassium was in treatments PSB+CU and PSB+Rhz (434.80 and 431.80 kg ha^{-1}).

Table 4.04 Effect of soybean cropping under INM system on the Physico-chemical properties of the soil

Factors	pH		EC_{25} ($dS\ m^{-1}$)		Organic Carbon (%)		AvailableP_2O_5 ($kg\ ha^{-1}$)		Available K_2O ($kg\ ha^{-1}$)	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-97	1998-99
Levels of Fertilizers (F):										
F_0	7.40	7.88	0.25	0.11	0.52	0.16	23.41	24.96	366.10	399.20
F_1	7.14	7.65	0.16	0.09	0.87	0.22	39.74	27.15	419.70	436.30
F_2	7.24	7.90	0.22	0.08	0.71	0.22	40.15	26.44	403.10	459.50
	*	NS	*	NS	*	*	*	NS	*	NS
Forms of manure (C):										
C_0	7.50	8.05	0.27	0.12	0.45	0.19	18.74	21.44	335.10	441.90
. C_1	7.20	7.90	0.15	0.07	0.72	0.20	37.11	30.37	394.40	405.20
C_2	7.09	7.49	0.20	0.09	0.93	0.21	47.44	26.74	459.40	440.00
	*	NS	*	*	*	NS	*	NS	*	NS
Biofertilizers and/or organic spray (B):										
B_0	7.31	7.72	0.21	0.18	0.57	0.18	29.04	24.26	365.40	428.40
B_1	7.25	7.90	0.26	0.08	0.70	0.20	35.30	26.30	399.40	431.80
B_2	7.22	7.82	0.16	0.09	0.82	0.22	38.96	28.00	424.20	434.80
	*	NS	*	*	*	NS	*	NS	*	NS
SEd ±	0.008	0.255	0.007	0.012	0.010	0.018	0.639	3.974	5.487	25.27
CD(0.05)	0.017	-	0.015	0.024	0.021	0.037	1.282	-	11.012	-
FxC FxB CxB:										
SEd ±	0.014	0.443	0.013	0.021	0.018	0.031	1.107	6.883	9.505	43.78
CD(0.05)	0.030	0.889	0.027	0.043	0.037	0.064	2.221	13.81	19.070	87.860

*Significant at P = 0.05 NS = non-significant

4.1.4.3 Interaction effect due to fertilizer levels and manurial forms

Table 4.04.1(a) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (soybean) status of soil EC_{25} (dS m^{-1})**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.382	0.201	0.176	0.253	0.146	0.091	0.101	0.113
F_1	0.210	0.154	0.117	0.160	0.124	0.080	0.077	0.094
F_2	0.230	0.117	0.336	0.227	0.102	0.068	0.096	0.089
Mean	0.274	0.157	0.209		0.124	0.080	0.091	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.014	0.027			0.022	0.043	

The EC_{25} in the 1st year was significantly effected as a result of interaction and the treatment combinations 33% RDF with FC+PM and 100% RDF with FC+VC were equally effective in lowering the values. All other treatments were comparable to each other [Table 4.04.1(a)]

In the 2nd year however, treatment combination 100% RDF with FC+VC proved to be the most effective. Treatment combination 33% with FC+PM and with FC+VC, FC+VC alone, FC+PM alone and with 100% RDF, and 100% RDF alone were statistically at par with the most effective treatment.

Table 4.04.1(b) Effect of interaction of fertilizer levels and manurial forms on post-cropping (soybean) status of soil organic carbon (%)

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.237	0.574	0.770	0.527	0.138	0.189	0.164	0.164
F_1	0.663	0.882	1.070	0.872	0.236	0.203	0.231	0.223
F_2	0.460	0.710	0.967	0.712	0.226	0.226	0.232	0.228
Mean	0.453	0.722	0.936		0.200	0.206	0.209	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.019	0.037			0.032	0.064	

With regard to the % organic carbon status [Table 4.04.1(b)] as influenced by the interaction effect, 33% RDF with FC+PM was the most effective (1.070%), which was significantly better than 100% RDF with FC+PM combination (0.967%), which in turn was better than treatment combination 33% RDF with FC+VC (0.882%), which in turn again was superior to FC+PM alone (0.770%). This trend was observed in all successive combinations.

In the 2nd year however, the treatment 33% RDF proved to be the most effective, and treatment combinations 33% RDF with FC+PM and with FC+VC, 100% RDF

alone, with FC+PM and with FC+VC and FC+VC alone were statistically comparable with it. The treatment FC+PM was again better than control.

Table 4.04.1(c) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (soybean) status of available P_2O_5 (kg ha^{-1}) of soil**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	8.67	24.78	36.78	23.41	14.89	29.11	30.89	24.96
F_1	22.22	43.67	53.33	39.74	24.22	34.67	22.56	27.15
F_2	25.33	42.89	52.22	40.15	25.22	27.33	26.78	26.44
Mean	18.74	37.11	47.44		21.44	30.37	26.74	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		1.11	2.22			6.88	13.81	

The available phosphorus status of the soil after the harvest of the soybean crop in the system was significantly effected as a result of interaction [Table 4.04.1(c)]. The highest value (53.33 kg ha^{-1}) was registered by the treatment combination 33% RDF with FC+PM. This was followed by 100% RDF with FC+PM combination (52.22 kg ha^{-1}), which was statistically comparable to the most effective combinaton. The treatment combinations 33% RDF with FC+VC (43.67 kg ha^{-1}) and 100% RDF with FC+VC (42.89 kg ha^{-1}) were the next best and were on par with each other.

In the 2nd year there was significant difference between all the treatment combinations and control. The maximum figures were recorded in treatment 33% RDF with FC+VC (34.67 kg ha^{-1}) and the minimum in control (14.89 kg ha^{-1}).

Table 4.04.1(d) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (soybean) status of available K_2O (kg ha^{-1}) of soil**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	296.00	374.30	427.90	366.07	389.60	380.30	427.80	399.23
F_1	354.70	416.90	487.70	419.77	451.80	397.80	459.30	436.30
F_2	354.70	392.00	462.80	403.17	508.20	437.40	432.90	459.50
Mean	335.13	394.40	459.47		449.87	405.17	440.00	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		9.51	19.08			43.78	87.87	

In the 1st year the available potassium status of soil [Table 4.04.1(d)] ranged from 296.00 kg ha^{-1} in control to 487.70 kg ha^{-1} in treatment combination 33% RDF with FC+PM. Significant difference was observed between the most effective treatment and treatment combination 100% RDF with FC+PM. However, this latter treatment was significantly better over treatment FC+PM alone. Again, the treatment combination

33% with FC+VC was statistically comparable with treatment FC+PM alone. In general all treatment combinations were superior to control.

In the 2nd year the maximum value was obtained in the treament 100% RDF alone and this was significantly above the treatment combination 33% RDF with FC+VC. However, treatments 33% RDF alone and with FC+PM, 100% RDF with FC+VC and with FC+PM, and FC+PM alone were statistically equivalent to the treatment 100% RDF.

4.1.4.4 Interaction effect of fertilizer levels and biofertilizer and/or organic spray

Table 4.04.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (soybean) status of soil EC_{25} (dS m^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.279	0.258	0.222	0.253	0.164	0.101	0.072	0.113
F_1	0.179	0.161	0.141	0.160	0.076	0.091	0.114	0.094
F_2	0.177	0.376	0.130	0.227	0.116	0.056	0.094	0.089
Mean	0.212	0.265	0.164		0.119	0.083	0.094	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.014	0.027			0.022	0.043	

Significant difference among treatment combinations was observed as a result of interaction between fertilizer levels and biofertilizer and/or organic spray [Table 4.04.2(a)]. The treatment combination 100% RDF with PSB+CU was significantly superior over treatment combination 33% RDF with PSB+Rhz. However, 33% RDF with PSB+CU was on par with the most effective treatment. Further, treatments 100% RDF alone and 33% RDF alone were statistically comparable with treatment combination with 33% with PSB+Rhz.

In the 2nd year the most effective treatment in terms of reducing the EC_{25} was 100% RDF with PSB+Rhz combination, which was statistically superior to treatment FC+VC alone. The treatments PSB+CU alone and with 100% RDF, 33% RDF alone and with PSB+Rhz were statistically comparable with the most effective treatment combination.

The % organic carbon was apparently affected by the interaction of levels of fertilizer and biofertilizer and/or organic spray [Table 4.04.2(b)]. The treatment combination 33% RDF with PSB+CUwas significantly better than 33% RDF with PSB+Rhz, which in turn was superior to 100% RDF with PSB+CU.

Table 4.04.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (soybean) status of soil organic carbon (%)**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.412	0.502	0.667	0.527	0.133	0.183	0.174	0.164
F_1	0.724	0.909	0.982	0.872	0.240	0.191	0.239	0.223
F_2	0.597	0.717	0.823	0.712	0.191	0.243	0.249	0.228
Mean	0.578	0.709	0.824		0.188	0.206	0.221	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.019	0.037			0.032	0.064	

In the 2nd year there was perceptible influence of the treatments on the post-cropping % organic carbon status of the soil. Treatment combination 100% RDF with PSB+CU was significantly better than treatment PSB+Rhz alone. However, treatments 100% RDF alone and with PSB+Rhz, 33% RDF alone, with PSB+Rhz and with PSB+CU were statistically comparable with the most effective treatment.

In the 1st year the available phosphorus status was significantly effected as a result of interaction and treatment combination 100% RDF with PSB+CU produced the highest (45.44 kg ha^{-1}) followed by 33% RDF with PSB+CU combination (44.33 kg ha^{-1}), both of which were comparable statistically [Table 4.04.2(c)]. Further, treatments PSB+Rhz with 100% RDF combination and with 33% RDF combination were on par with each other and statistically superior to treatment 33% RDF alone. All treatments were better than control (19.67 kg ha^{-1}).

Table 4.04.2(c) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (soybean) status of soil available P_2O_5 (kg ha^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	19.67	23.44	27.11	23.41	21.78	28.33	24.78	24.96
F_1	33.89	41.00	44.33	39.74	25.67	18.44	37.33	27.15
F_2	33.56	41.44	45.44	40.15	25.33	32.11	21.89	26.44
Mean	29.04	35.29	38.96		24.26	26.29	28.00	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		1.11	2.22			6.88	13.81	

In the 2nd year the most effective treatment with regard to available phosphorus status of the soil, was treatment combination 33% RDF with PSB+CU. Treatments 100% RDF alone and with PSB+Rhz, 33% RDF alone, PSB+Rhz alone and PSB+CU alone were found to be statistically on par with the most effective treatment.

During the 1st year the data on post-cropping available potassium status of soil revealed that there was influence of the interaction between the factors [Table 4.04.2(d)]. Treatment 33% RDF with PSB+CU registered the highest value of 452.40

kg ha^{-1}, which was signficantly higher than treatment combination with 100% RDF with PSB+CU. However, treatment 33% RDF with PSB+Rhz was at par with this 2nd best treatment. Treatments 100% RDF with PSB+Rhz, 33% RDF alone, PSB+CU alone and PSB+Rhz alone were on par with each other and was better than control.

Table 4.04.2(d) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (soybean) status of soil available K_2O (kg ha^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	323.10	382.60	392.60	366.10	355.80	428.80	413.10	399.23
F_1	392.60	414.20	452.40	419.73	460.30	428.40	420.10	436.27
F_2	380.60	401.30	427.60	403.17	469.20	438.10	471.20	459.50
Mean	365.43	399.37	424.20		428.43	431.77	434.80	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		9.51	19.08			43.78	87.87	

In the 2nd year however, the best treatment was 100% RDF with PSB+CU (471.20 kg ha^{-1}), and all other treatment combinations were statistically comparable with this treatment and were superior to control (355.80 kg ha^{-1}).

4.1.4.2 Interaction effect of manurial forms and biofertilizer and/or organic spray

Table 4.04.3(a) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (soybean) status of soil EC_{25} (dS m^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.313	0.287	0.222	0.274	0.148	0.103	0.121	0.124
C_1	0.179	0.156	0.138	0.157	0.100	0.073	0.066	0.080
C_2	0.142	0.352	0.133	0.209	0.108	0.071	0.094	0.091
Mean	0.211	0.265	0.164		0.119	0.083	0.094	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.014	0.027			0.022	0.043	

The status of EC_{25} of the post-cropping field of soybean in the system in the 1st year showed significant difference as a result of interaction between manurial levels and biofertilizer and/or organic spray [Table 4.04.3(a)]. The most effective treatment was FC+PM with PSB+CU, which was significantly better than treatment FC+VC alone. Treatment combinations FC+VC with PSB+CU and with PSB+Rhz and treatment FC+PM alone were statistically comparable with the most effective treatment combinations.

In the 2nd year the treatment combinations FC+VC with PSB+CU registered the least value of EC_{25} (0.066), which was significantly below the treatment PSB+CU

alone. The treatment combinations FC+PM alone, with PSB+Rhz and with PSB+CU, treatments FC+VC alone and with PSB+Rhz, and PSB+Rhz alone were statistically on par with the most effective treatment.

Table 4.04.3(b) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (soybean) status of soil organic carbon (%)**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.260	0.462	0.638	0.453	0.147	0.202	0.250	0.200
C_1	0.676	0.718	0.773	0.722	0.218	0.207	0.193	0.206
C_2	0.798	0.948	1.061	0.936	0.200	0.209	0.219	0.209
Mean	0.578	0.709	0.824		0.188	0.206	0.221	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.019	0.037			0.032	0.064	

In the 1st year the % organic carbon status of the soil was found to have significant difference between the different treatment combination forming factors. The treatment FC+PM with PSB+CU was the most effective combination and was significantly better than all other combinations [Table 4.04.3(b)]. The 2nd best treatment combination was FC+PM with PSB+Rhz. Further, treatment FC+PM alone and FC+VC with PSB+CU, both of which were statistically comparable with each other.

In the 2nd year the treatment PSB+CU alone registered the maximum% organic carbon (0.250) and all other treatments were statistically comparable with the most effective treatment and significantly different over control (0.147).

Table 4.04.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (soybean) status of soil available P_2O_5 (kg ha^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	11.11	20.56	24.56	18.74	14.56	28.89	20.89	21.45
C_1	30.78	37.67	42.89	37.11	31.56	23.89	35.67	30.37
C_2	45.22	47.67	49.44	47.44	26.67	26.11	27.44	26.74
Mean	29.04	35.30	38.96		24.26	26.30	28.00	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		1.11	2.22			6.88	13.81	

Significant difference between treatments was observed with regard to the soil status of available phosphorus [Table 4.04.3(c)]. The treatment combinations FC+PM with PSB+CU recorded the maximum value (49.44 kg ha^{-1}), followed by FC+PM with PSB+Rhz (47.67), both of which were on par with each other and significantly superior to FC+PM alone.

In the 2nd year the treatment combination FC+VC with PSB+CU registered the maximum (35.67). All other treatments, except that of PSB+CU alone, were statistically superior to control

Table 4.04.3(d) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (soybean) status of soil available K_2O (kg ha^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	297.40	337.60	370.30	335.10	426.40	455.70	467.40	449.83
C_1	374.30	392.00	416.90	394.40	401.70	407.00	406.90	405.20
C_2	424.40	468.60	485.30	459.43	457.20	432.70	430.10	440.00
Mean	365.37	399.40	424.17		428.43	431.80	434.80	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		9.51	19.08			43.78	87.87	

The data on post-cropping soil status of available potassium [Table 4.04.3(d)] revealed that the treatments FC+PM with PSB+CU (485.30 kg ha^{-1}) and with PSB+Rhz (468.60 kg ha^{-1}) were the best two treatment combinations which were on par with each other and significantly different from FC+PM alone (424.40 kg ha^{-1}). However, treatment combination FC+VC with PSB+CU (416.90 kg ha^{-1}) was statistically at par with FC+PM alone.

In the 2nd year however, no significant difference between the treatment combinations, with regard to available potassium was observed. However, the maximum figures were recorded in treatment PSB+CU alone (467.40 kg ha^{-1}) and minimum in treatment FC+VC alone (401.70 kg ha^{-1}).

4.2 **Experiment 1:** **(Soybean – Mustard – Fodder cowpea system)**
Crop component 2: Mustard

4.2.1' Dry matter accumulation

4.2.1.1 Fertilizer levels

Throughout the crop period in both the years (Table 4.05), except at 15 DAS in the 1^{st} year, there was significant difference in the plant dry weight values as influenced by the different levels of fertilizers. The maximum values were registered invariably in combinations with 100% RDF, except at 15 and 45 DAS in the 1^{st} year when these values were found to be the highest with combinations with 33% RDF. Dry weight values were statistically comparable in the two levels (100 & 33% RDF) at 45, 75 and 105 DAS during the 1^{st} year and at 30 DAS in the 2^{nd} year.

4.2.1.2 Manurial forms

Significant variation due to the different manurial forms was apparent at 60 DAS in the 1st year and at 15, 30, 45 &75 DAS in the 2^{nd} year (Table 4.05). In all these stages except at 15 DAS the FC+VC combination proved to be effective in higher dry matter accumulation. However, these were statistically comparable with the treatment combination with FC+PM. The combinations with FC+VC was responsible for maximum values at 30, 45, 60 DAS in the 1^{st} year and 60 and 105 DAS in the 2^{nd} year. However, the FC+PM combination produced highest dry weight at 15, 75, and 90 DAS during 1st year and 75 and 90 DAS during the 2^{nd} year.

4.2.1.3 Biofertilizer and/or organic spray

Only at 15 DAS in the 1^{st} year there was significant difference between the treatments (Table 4.05), during which the PSB+CU combination produced the highest value (0.157 g/plant). However, the value was statistically comparable with the treatment PSB+Azsp. The PSB+CU combination produced maximum values at 45, 75 and 90 DAS in the 1^{st} year and at 75 and 105 DAS in the 2^{nd} year. The treatment combination with PSB+Azsp registered highest dry weight values at 30 and 105 DAS in the 1^{st} year and at 15, 30 and 90 DAS in the 2^{nd} year.

Table 4.05 **Effect of INM on dry weight of mustard (g/plant) during 1997-98 and 1998-99**

Factors	15 DAS		30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Levels of Fertilizers (F):														
F_0	0.105	0.425	0.248	0.702	0.812	1.142	4.519	4.717	4.662	8.588	12.61	15.88	26.43	45.63
F_1	0.147	0.602	0.359	1.352	1.163	2.190	6.245	8.835	9.011	15.97	21.78	24.25	52.56	68.60
F_2	0.145	0.670	0.360	1.551	1.065	2.751	7.835	13.25	10.63	25.56	27.33	37.65	57.58	113.10
	NS	*	*	*	*	*	*	*	*	*	*	*	*	*
Forms of manure (C):														
C_0	0.120	0.474	0.311	1.018	0.949	1.633	3.974	8.076	8.398	15.09	21.14	25.58	48.83	70.23
C_1	0.131	0.633	0.362	1.391	1.139	2.421	7.336	9.527	7.733	16.81	19.12	25.00	42.48	78.83
C_2	0.145	0.591	0.295	1.197	0.952	2.009	7.289	9.204	8.170	18.22	21.46	27.20	45.25	78.32
	NS	*	NS	*	NS	*	*	NS	NS	*	NS	NS	NS	NS
Biofertilizers and/or organic spray (B):														
B_0	0.096	0.558	0.300	1.119	1.005	2.045	6.447	9.072	7.970	15.78	20.13	23.76	44.96	73.67
B_1	0.144	0.588	0.334	1.268	1.017	2.029	6.219	8.762	7.231	16.92	19.42	27.89	47.06	73.87
B_2	0.157	0.551	0.333	1.220	1.019	2.009	5.932	8.972	9.095	17.41	22.18	26.13	44.55	79.85
	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEd ±	0.0224	0.0483	0.0381	0.1161	0.0982	0.2062	0.5721	1.0210	1.1980	1.4350	2.0554	2.6933	3.6870	6.8930
CD(0.05)	0.0450	0.0970	0.0765	0.2331	0.19708	0.4138	1.148	2.0489	2.4039	2.8800	4.1244	5.4045	7.3980	13.8330
FxC FxB CxB:														
SEd ±	0.0389	0.0838	0.0660	0.2012	0.1701	0.3572	0.9910	1.7680	2.0750	2.4870	3.5600	4.6650	6.3860	11.940
CD(0.05)	0.0780	0.1681	0.1326	0.4024	0.3413	0.7169	1.9880	3.5480	4.1640	4.9910	7.1440	9.3620	12.810	23.963

*Significant at P = 0.05 NS = non-significant

4.2.1.3 Interaction effect of fertilizer levels and manurial forms

Table 4.05.1(a) Effect of interaction of fertilizer levels and manurial forms on dry weight of mustard (g/plant) at 15 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.082	0.133	0.100	0.105	0.247	0.566	0.464	0.426
F_1	0.166	0.136	0.140	0.147	0.609	0.518	0.681	0.603
F_2	0.113	0.127	0.197	0.146	0.568	0.816	0.628	0.670
Mean	0.120	0.132	0.146		0.474	0.633	0.591	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.039	0.078			0.084	0.168	

Significant difference as a result of interaction between the two factors, i.e., fertilizer levels and manurial forms was observed [Table 4.05.1(a)]. Treatment combination 100% RDF with FC+PM registered the maximum value of plant dry weight (0.197 g). Treatments 33% RDF alone, with FC+PM and with FC+VC, FC+VC alone and with 100% RDF were statistically comparable with the most effective treatment.

During the 2nd year the treatment combination 100% RDF with FC+VC produced the highest value (0.816) followed by 33% RDF with FC+PM combination (0.681) both of which were on par with each other and significantly higher than 100% with FC+PM (0.628). However, the rest of the treatments were statistically comparable with treatment 100% RDF with FC+PM and superior over control (0.247).

Table 4.05.1(b) Effect of interaction of fertilizer levels and manurial forms on dry weight of mustard (g/plant) at 30 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.24	0.28	0.22	0.25	0.45	0.83	0.82	0.70
F_1	0.35	0.35	0.37	0.36	1.41	1.33	1.31	1.35
F_2	0.34	0.45	0.29	0.36	1.19	2.01	1.46	1.55
Mean	0.31	0.36	0.30		1.02	1.39	1.20	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.07	0.13			0.20	0.40	

At 30 DAS during the 1st year the treatment combination 100% RDF with FC+VC registered the highest value (0.451) and was significantly above treatment 100% RDF with FC+PM combination. However, treatments 33% RDF alone, with FC+PM and with FC+VC and 100% RDF alone were statistically comparable with the treatment 100% RDF with FC+VC [Table 4.05.1(b)].

During the 2nd year treatment 100% RDF with FC+VC was most effective, and highly significant above treatment 100% RDF with FC+PM combination. However, treatments 33% RDF alone, with FC+VC and with FC+PM and 100% RDF alone were statistically at par with 100% RDF with FC+PM treatment combination.

Table 4.05.1(c) **Effect of interaction of fertilizer levels and manurial forms on dry weight of mustard (g/plant) at 45 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.66	1.05	0.73	0.81	0.58	1.76	1.09	1.14
F_1	1.18	1.15	1.15	1.16	2.18	2.19	2.20	2.19
F_2	1.00	1.22	0.97	1.07	2.20	3.32	2.74	2.75
Mean	0.95	1.14	0.95		1.65	2.42	2.01	
		SEd ± 0.17	CD(0.05) 0.34			SEd ± 0.36	CD(0.05) 0.72	

In the 1st year at 45 DAS the treatment combination 100% RDF with FC+VC recorded the highest plant dry weight value (1.218 g) and was signficantly different than treatment FC+PM alone. All other treatments were statistically comparable to the treatment 100% RDF with FC+PM [Table 4.05.1(c)].

In the 2nd year the treatment combination 100% RDF with FC+VC recorded the highest value (3.319 g) followed by 100% RDF with FC+PM (2.738 g), both of which were on par with each other and significantly superior to treatment combination 33% RDF with FC+PM. All other treatments, except FC+PM alone were statistically comparable with the treatment 33% RDF with FC+PM.

Table 4.05.1(d) **Effect of interaction of fertilizer levels and manurial forms on dry weight of mustard (g/plant) at 60 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	1.74	6.62	5.20	4.52	3.37	5.74	5.04	4.72
F_1	4.70	5.80	8.24	6.25	7.84	9.45	9.21	8.83
F_2	5.49	9.58	8.44	7.84	13.01	13.38	13.37	13.25
Mean	3.97	7.34	7.29		8.08	9.53	9.20	
		SEd ± 0.99	CD(0.05) 1.99			SEd ± 1.77	CD(0.05) 3.55	

At 60 DAS in the 1st year the treatment combination 100% RDF with FC+VC was significantly different from that of treatment FC+VC alone in terms of plant dry weight values [Table 4.05.1(d)]. Treatments FC+PM with 100% RDF and with 33% RDF were statistically at par with treatment 100% RDF with FC+VC. The rest of the

treatments were comparable with treatment FC+VC alone and significantly superior to control.

During the 2nd year the 100% RDF combinations registered statistically superior plant dry weight values than the 33% RDF combinations. However, the 33% RDF combinations were statistically better than the 0 level fertilizer combinations.

Table 4.05.1(e) **Effect of interaction of fertilizer levels and manurial forms on dry weight of mustard (g/plant) at 75 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	3.89	4.94	5.16	4.66	4.87	8.94	11.95	8.59
F_1	8.33	8.47	10.23	9.01	15.23	15.86	16.81	15.97
F_2	12.98	9.79	9.12	10.63	25.17	25.62	25.88	25.56
Mean	8.40	7.73	8.17		15.09	16.81	18.21	
		SEd ± 2.08	CD(0.05) 4.16			SEd ± 2.49	CD(0.05) 4.99	

At 75 DAS in the 1st year there was significant difference in the plant dry weight due to the interaction of fertilizer levels and manurial forms [Table 4.05.1(e)]. Though the treatment with 100% RDF alone registered the highest value (12.98), treatment combinations 33% RDF with FC+PM (10.23), 100% RDF with FC+VC (9.785) and with FC+PM (9.122) were statistically comparable with the treatment with highest figures. The rest of the treatments were on par with each other and superior to control.

The treatment combinations with 100% RDF proved significantly effective over the treatment combinations with 33% RDF during the 2nd year. However, the treatment combinations 33% RDF alone, with FC+PM and with FC+VC and treatment FC+PM alone were on par with each other and significantly superior to control.

Table 4.05.1(f) **Effect of interaction of fertilizer levels and manurial forms on dry weight of mustard (g/plant) at 90 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	7.75	16.04	14.04	12.61	9.34	21.48	16.81	15.88
F_1	25.26	17.87	22.22	21.78	26.29	21.48	24.98	24.25
F_2	30.43	23.45	28.11	27.33	41.12	32.03	39.81	37.65
Mean	21.15	19.12	21.46		25.58	25.00	27.20	
		SEd ± 3.56	CD(0.05) 7.14			SEd ± 4.67	CD(0.05) 9.36	

At 90 DAS in the 1st year the treatment 100% RDF registered signifcantly higher plant dry weight than treatment 33% RDF with FC+PM combination. The

treatments 100% RDF alone and with FC+PM and 33% RDF alone were comparable with the most effective treatment. The rest of the treatments, except FC+PM alone were comparable with the 33% RDF with FC+PM combination [Table 4.05.1(f)].

In the 2nd year again the treatment 100% RDF alone and combinations proved significantly superior to treatment 33% RDF alone. All the rest of the treatments, except FC+PM alone were statistically comparable with 33% RDF alone.

Table 4.05.1(g) **Effect of interaction of fertilizer levels and manurial forms on dry weight of mustard (g/plant) at 105 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	20.52	31.83	26.94	26.43	31.28	57.18	48.43	45.63
F_1	65.11	41.52	51.03	52.55	76.15	55.86	73.80	68.60
F_2	60.87	54.09	57.76	57.57	103.30	123.40	112.70	113.13
Mean	48.83	42.48	45.24		70.24	78.81	78.31	
		SEd ± 6.39	CD(0.05) 12.82			SEd ± 11.94	CD(0.05) 23.96	

At 105 DAS in the 1st year the treatment 33% RDF alone exhibited a marked influence on the plant dry weight value (65.11 g). The treatments 100% RDF alone, with FC+PM and with FC+VC were statistically at par with the most effective treatment. Further, the treatment combinations 33% RDF with FC+PM and with FC+VC were on par with each other and were better than the 0 level fertilizer combinations [Table 4.05.1(g)].

However, in the 2nd year the treatment combinations with 100% RDF were found to be significantly more effective than treatment with 33% RDF alone. However, the treatments 33% RDF with FC+PM and with FC+VC and treatment FC+VC alone were statistically equivalent with the treatment 33% RDF alone, which were in turn superior to control.

4.2.1.4 Interaction effect of levels of fertilizer and biofertilizer and/or organic spray

In the 1st year at 15 DAS there was significant difference between the treatments as a result of interaction between fertilizer levels and biofertilizer and/or organic spray [Table 4.05.2(a)]. The treatment combination 100% RDF with PSB+Azsp registered the maximum plant dry weight and was significantly higher than treatment 33% RDF alone.

However, treatments 33% RDF with PSB+CU and with PSB+Azsp, PSB+CU alone and with 100% RDF was statistically on par with the most effective treatment.

Table 4.05.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 15 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.082	0.073	0.160	0.105	0.379	0.444	0.453	0.426
F_1	0.109	0.161	0.171	0.147	0.530	0.734	0.543	0.603
F_2	0.099	0.198	0.140	0.146	0.768	0.586	0.658	0.670
Mean	0.097	0.144	0.157		0.559	0.588	0.551	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.039	0.078			0.084	0.168	

In the 2nd year the figures in treatment 100% RDF alone was significantly higher over treatment 100% RDF with PSB+Azsp. The treatments 33% RDF with PSB+Azsp and 100% RDF with PSB+CU were comparable with the treatment 100% RDF alone. However, all other treatments were at par with treatment 100% RDF with PSB+Azsp.

Table 4.05.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 30 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.28	0.22	0.25	0.25	0.66	0.70	0.75	0.70
F_1	0.34	0.34	0.39	0.36	1.28	1.47	1.31	1.35
F_2	0.28	0.44	0.36	0.36	1.42	1.63	1.61	1.55
Mean	0.30	0.33	0.33		1.12	1.27	1.22	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.07	0.13			0.20	0.40	

In the 1st year at 30 DAS the treatment combination 100% RDF with PSB+Azsp recorded significantly higher value (0.438 g) than the treatment 100% RDF alone [Table 4.05.2(b)]. The treatments 33% RDF alone, with PSB+CU and with PSB+Azsp and 100% RDF with PSB+CU were statistically at par with the most effective treatment.

In the 2nd year the same treatment proved to be most effective in obtaining the highest plant dry weight (1.631g). The treatments 100% RDF alone and with PSB+CU, 33% RDF alone, with PSB+Azsp and with PSB+CU combinations were statistically at par with the best treatment.

At 45 DAS during the 1st year there was marked difference between the various combinations as a result of interaction between fertilizer levels and biofertilizer and/or organic spray. The treatment 33% RDF alone registered the highest dry weight figure.

However, the treatment combinations 100% RDF with PSB+CU and with PSB+Azsp, 33% RDF with PSB+Azsp and with PSB+CU were statistically comparable with the most effective treatment [Table 4.05.2(c)].

Table 4.05.2(c) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 45 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.77	0.82	0.85	0.81	1.20	1.14	1.09	1.14
F_1	1.32	1.12	1.05	1.16	2.12	2.27	2.18	2.19
F_2	0.93	1.11	1.15	1.06	2.82	2.68	2.76	2.75
Mean	1.01	1.02	1.02		2.05	2.03	2.01	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.17	0.34			0.36	0.72	

In the 2nd year the treatment 100% RDF alone registered the maximum plant dry weight. Treatments 100% RDF with PSB+CU and with PSB+Azsp, and all the combinations with 33% RDF were statistically comparable with the treatment with maximum dry weight, and were superior to the control and 0 level RDF combinations.

In the 1st year at 60 DAS the treatment 100% RDF alone was significantly better than the treatment combination 100% RDF with PSB+CU [Table 4.05.2(d)]. However, the treatments 100% RDF with PSB+Azsp and 33% RDF with PSB+CU were statistically comparable with the 100% RDF alone. The treatments 100% RDF with PSB+CU, 33% RDF alone and with PSB+Azsp and PSB+Azsp alone were on par with treatment 100% RDF with PSB+CU.

Table 4.05.2(d) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 60 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	4.68	4.82	4.05	4.52	3.87	4.84	5.44	4.72
F_1	5.76	5.90	7.07	6.25	8.31	8.63	9.57	8.84
F_2	8.89	7.93	6.68	7.83	15.04	12.81	11.91	13.25
Mean	6.45	6.22	5.93		9.07	8.76	8.97	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.99	1.99			1.77	3.55	

In the 2nd year again the treatment 100% RDF proved to be the most effective and significantly better than treatment 33% RDF with PSB+CU. However, treatment combinations 100% RDF with PSB+Azsp and with PSB+CU were comparable. Further, the treatments 33% RDF alone and with PSB+Azsp were comparable with the 2nd best category, i.e., 33% RDF with PSB+CU.

Table 4.05.2(e) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 75 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	4.30	4.21	5.47	4.66	7.34	7.42	11.00	8.59
F_1	8.20	8.64	10.19	9.01	15.63	16.47	15.81	15.97
F_2	11.40	8.86	11.62	10.63	24.35	26.89	25.43	25.56
Mean	7.97	7.24	9.09		15.77	16.93	17.41	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		2.08	4.16			2.49	4.99	

At 75 DAS during the 1st year significant difference between treatments was observed due to the interaction of fertilizer levels and biofertilizer and/or organic spray. Treatment 100% RDF with PSB+CU registered the maximum value (11.62 g). All other treatment combinations with both 100% RDF and 33% RDF were superior to treatments with 0 level fertilizer combinations [Table 4.05.2(e)].

In the 2nd year almost similar trend was observed with treatment combinations involving 100% RDF performed significantly superior than combinations with 33% RDF, which in turn were significantly superior to combinations with 0 level RDF and control.

At 90 DAS in the 1st year the treatment 100% RDF alone was significantly better than 33% RDF alone. However, the treatments 100% RDF with PSB+CU and with PSB+Azsp, 33% RDF with PSB+Azsp and with PSB+CU were statistically comparable with the most effective treatment [Table 4.05.2(f)].

Table 4.05.2(f) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 90 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	11.80	10.94	15.09	12.61	13.76	17.28	16.59	15.88
F_1	19.38	23.25	22.72	21.78	23.66	27.89	21.19	24.25
F_2	29.21	24.06	28.72	27.33	33.85	38.50	40.62	37.66
Mean	20.13	19.42	22.18		23.76	27.89	26.13	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		3.56	7.14			4.67	9.36	

In the 2nd year the treatment combinations with 100% RDF registered significantly higher figures over treatments with 33% RDF. Nevertheless, the combinations with 33% RDF were significantly superior to the combinations 0 level RDF.

Table 4.05.2(g) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 105 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	23.61	24.84	30.84	26.43	43.49	38.03	55.38	45.63
F_1	47.82	58.04	51.81	52.56	70.29	67.68	67.83	68.60
F_2	63.44	58.31	50.98	57.58	107.20	115.90	116.30	113.13
Mean	44.96	47.06	44.54		73.66	73.87	79.84	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		6.39	12.82			11.94	23.96	

At 105 DAS in the 1st year treatment 100% RDF alone (63.44 g) was significantly better than treatment 33% RDF (47.82). Treatments 100% RDF with PSB+Azsp (58.31) and with PSB+CU (50.98), 33% RDF with PSB+Azsp (58.04) and with PSB+CU (51.81) were statistically comparable with the most effective treatment [Table 4.05.2(g)].

In the 2nd year the treatment combination 100% RDF with PSB+CU (116.30) registered significantly higher figures than treatment 33% RDF alone (70.29). The treatments 100% RDF alone and with PSB+Azsp were on par with the most effective treatment combination. Treatments 33% RDF with PSB+CU and with PSB+Azsp and PSB+CU alone were statistically comparable with 100% RDF alone.

4.2.1.5 Interaction effect of manurial forms and biofertilizer and/or organic spray

Table 4.05.3(a) Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 15 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.111	0.106	0.144	0.120	0.247	0.566	0.464	0.426
C_1	0.096	0.136	0.164	0.132	0.609	0.518	0.681	0.603
C_2	0.083	0.191	0.162	0.146	0.568	0.816	0.628	0.670
Mean	0.097	0.144	0.157		0.474	0.633	0.591	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.039	0.078			0.084	0.168	

Signicficant difference between treatment combinations was perceivable at 15 DAS during the 1st year as a result of interaction between manurial forms and biofertlizer and/or organic spray. The treatment FC+PM with PSB+Azsp registered the highest value (0.191). Treatments FC+VC with PSB+CU and with PSB+Azsp, PSB+CU alone and with FC+PM were statistically comparable with the most effective treatment combination [Table 4.05.3(a)].

In the 2nd year the treatment combination FC+VC with PSB+Azsp recorded the highest value and was significantly higher than FC+PM with PSB+CU combination. Treatment FC+VC with PSB+CU was statistically at par with the former. However, all other treatments, except PSB+CU alone were comparable with the treatment FC+VC with PSB+CU.

Table 4.05.3(b) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 30 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.35	0.24	0.34	0.31	0.93	1.24	0.88	1.02
C_1	0.26	0.46	0.37	0.36	1.29	1.33	1.56	1.39
C_2	0.29	0.30	0.29	0.30	1.14	1.24	1.22	1.20
Mean	0.30	0.33	0.33		1.12	1.27	1.22	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.07	0.13			0.20	0.40	

At 30 DAS in the 1st year the treatment FC+VC with PSB+Azsp proved most effective and was significantly superior to PSB+CU alone [Table 4.05.3(b)]. Treatments PSB+CU alone and with FC+VC were statistically at par with the most effective treatment. However, the all other treatments were statistically comparable with FC+VC with PSB+CU combination.

All treatment combinations, except PSB+CU alone, were significantly superior to control during the 2nd year. The maximum figure was obtained in FC+VC with PSB+CU (1.556) and minimum in PSB+CU alone (0.884).

Table 4.05.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 45 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.97	0.90	0.98	0.95	1.91	1.72	1.33	1.65
C_1	1.12	1.18	1.12	1.14	2.42	2.34	2.50	2.42
C_2	0.93	0.97	0.96	0.95	1.80	2.03	2.19	2.01
Mean	1.01	1.02	1.02		2.05	2.03	2.01	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.17	0.34			0.36	0.72	

At 45 DAS in the 1st year no significant difference was observed as result of intereaction between the manurial forms and biofertilizer and/or organic spray [Table 4.05.3(c)]. However, the highest figures (1.178) were registered by treatment FC+VC with PSB+Azsp combination and the minimum in control (0.967).

However, in the 2nd year the treatment combination FC+VC with PSB+CU was significantly higher than treatment PSB+Azsp. Treatments FC+VC alone and with PSB+Azsp, FC+PM alone, with PSB+CU and with PSB+Azsp were statistically comparable with the most effective treatment.

Table 4.05.3(d) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 60 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	2.88	4.38	4.67	3.97	8.90	7.08	8.25	8.08
C_1	8.32	6.80	6.88	7.34	9.94	9.77	8.87	9.53
C_2	8.14	7.48	6.25	7.29	8.37	9.44	9.80	9.20
Mean	6.45	6.22	5.93		9.07	8.76	8.97	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		0.99	1.99			1.77	3.55	

At 60 DAS in the 1st year the data [Table 4.05.3(d)] pertaining to plant dry weight revealed that there was significant difference between the treatments as a result of interaction between the factors manurial levels and biofertilizer and/or organic spray. Treatment FC+VC alone registered the highest value (8.322) which was superior to treatment FC+PM with PSB+CU. Treatments FC+PM alone and with PSB+Azsp, FC+VC with PSB+CU and with PSB+Azsp were statistically comparable with the most effective treatment.

In the 2nd year however, no significant difference was observed between the different treatment combinations. Nevertheless, somewhat similar trend was observed with treatment FC+VC alone recording the maximum value (9.944).

Table 4.05.3(e) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 75 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	8.16	7.41	9.63	8.40	14.44	13.74	17.10	15.09
C_1	6.16	7.74	9.30	7.73	17.70	18.29	14.42	16.80
C_2	9.60	6.56	8.36	8.17	15.19	18.74	20.71	18.21
Mean	7.97	7.24	9.10		15.78	16.92	17.41	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		2.08	4.16			2.49	4.99	

At 75 DAS in the 1st year there was no significant difference between the treatment combinations [Table 4.05.3(e)]. However, the treatment PSB+CU alone registered the maximum (9.62) and the treatment FC+VC alone showed the minimum value (6.15).

However, in the 2nd year the treatment combination FC+PM with PSB+CU was significantly (20.71) higher than the treatment FC+PM (15.19) alone. The treatments FC+PM with PSB+Azsp, FC+VC alone and with PSB+Azsp and PSB+CU alone were statistically comparable with the most effective treatment.

Table 4.05.3(f) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 90 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	21.84	18.81	22.78	21.14	19.61	30.45	26.69	25.58
C_1	18.67	17.44	21.24	19.12	29.38	25.97	19.63	24.99
C_2	19.88	21.99	22.50	21.46	22.28	27.24	32.08	27.20
Mean	20.13	19.41	22.17		23.76	27.89	26.13	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		3.56	7.14			4.67	9.36	

In the1st year at 90 DAS, no significant difference was apparent as a result of the interaction [Table 4.05.3(f)]. However, the treatment PSB+CU alone registered the highest figure (22.78) and the minimum was in treatment FC+VC with PSB+Azsp (17.44).

In the 2nd year the treatment FC+PM with PSB+CU registered the highest (32.08) per plant dry weight value which was significantly better than treatment FC+PM alone (22.28). Treatments PSB+Azsp alone and with FC+PM, FC+VC alone and with PSB+Azsp and PSB+CU were statistically at par with the most effective treatment.

Table 4.05.3(g) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of mustard (g/plant) at 105 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	45.06	51.85	49.59	48.83	59.32	74.14	77.24	70.23
C_1	44.70	42.37	40.38	42.48	85.01	73.77	77.70	78.83
C_2	45.11	46.96	43.67	45.25	76.69	73.69	84.60	78.33
Mean	44.96	47.06	44.55		73.67	73.87	79.85	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		6.39	12.82			11.94	23.96	

At 105 DAS in the 1st year no significant difference between treatments were observed [Table 4.05.3(g)]. Treatment PSB+CU alone showed the maximum (51.85) and the minimum was obtained in FC+VC with PSB+CU combination (40.38).

In the 2nd year the treatment FC+VC alone (85.01) showed a significantly higher value than the control (59.32). All other combinations were statistically comparable with this treatment.

4.2.2 Yield and yield attributes

4.2.2.1 Fertilizer levels

All the parameters, *viz.*, branches per plant, pods per branch, test weight, seed yield and biological yield were markedly influenced by the different levels of fertilizer (Table 4.06). In both the years (1997-98 and 1998-99) treatment combinations with 100% RDF registered the highest figures of branches per plant (6.28 and 6.40 respectively), pods per branch (96.59 and 137.30 respectively), pods per plant (607.60 and 887.30 respectively), seed yield kg ha^{-1} (3017.00 and 3486.00 respectively) and biological yield kg ha^{-1} (10830.00 and 13270.00 respectively). However, the test weight value in the 1st year was higher (5.73) in treatment with 33% RDF than the treatment with 100% RDF (5.63) but both these were statistically comparable. There was statistical comparability of branches/plant and pods/plant under 33% RDF and 100% RDF in the 1st year.

The treatment 33% RDF registered significantly higher oil content in seeds of mustard over the control, which in turn was higher than 100% RDF (32.22, 31.54 and 31.16% respectively).

Table 4.06 **Effect of INM on the yield attributes and oil content in seed of mustard crop in the cropping system during 1997-98 and 1998-99**

Factors	Branches/plant		Pods/branch		Pods/plant		Test weight (g)		Seed yield (kg ha^{-1})		Biological yield (kg ha^{-1})		Oil content of seeds (%)
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1998-99
Fertilizer levels (F):													
F_0	5.15	5.00	51.45	82.58	271.30	427.40	4.965	5.048	746.90	1078.00	2864.00	4816.00	31.54
F_1	6.25	5.51	80.74	116.90	509.20	648.40	5.732	5.161	2181.00	2269.00	6967.00	8935.00	32.22
F_2	6.28	6.40	96.59	137.30	607.60	887.30	5.631	5.256	3017.00	3486.00	10830.0	13270.0	31.16
	*	*	*	*	*	*	*	*	*	*	*	*	*
Forms of manure (C):													
C_0	5.87	5.35	73.55	97.49	450.80	545.40	5.369	4.957	2006.00	2240.00	7519.00	8869.00	31.38
C_1	5.84	5.84	80.79	120.40	486.60	721.10	5.412	5.170	1901.00	2308.00	6406.00	9096.00	32.08
C_2	5.97	5.72	74.44	118.90	450.80	696.50	5.548	5.330	2037.00	2285.00	6733.00	9052.00	31.45
	NS	*	*	NS	NS	*	NS	*	NS	NS	NS	NS	*
Biofertilizer &/or organic spray (B):													
B_0	5.78	5.60	73.95	115.10	448.90	668.10	5.221	5.104	1997.00	2182.00	6746.00	8931.00	30.85
B_1	5.89	5.61	73.55	109.50	441.60	636.20	5.548	5.257	1911.00	2399.00	6493.00	9284.00	32.01
B_2	6.00	5.71	81.28	112.20	497.60	658.80	5.559	5.104	2037.00	2252.00	74200.0	8801.00	32.06
	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	*
SEd ±	0.1727	0.2029	6.667	6.612	45.358	50.056	0.1626	0.0218	134.28	160.06	523.85	486.90	0.0460
CD(0.05)	0.3465	0.4072	13.380	13.270	91.018	100.44	0.3264	0.0437	269.46	321.18	1051.20	976.81	0.0923
FxC FxB CxB:													
SEd ±	0.2992	0.3515	11.55	11.45	78.56	86.70	0.2818	0.0377	232.60	277.20	907.30	843.10	0.0796
CD(0.05)	0.6002	0.7054	23.18	22.98	157.66	174.00	0.5655	0.0758	466.82	556.30	1820.95	1692.10	0.1599

*Significant at P = 0 05 NS = non-significant

4.2.2.2 Manurial forms

In the 1st year the different forms of manure significantly affected none of the parameters (Table 4.06). On a closer perusal of the data in the 1st year, the treatment FC+PM registered the higher value of branches/plant (5.97), test weight (5.54 g), seed yield (2037.00 kg ha^{-1}) and the treatment FC+VC recorded higher values of pods/branch (80.79) and pods/plant (486.60). However, in the 2nd year the different forms of manure significantly influenced most of the parameters. Branches/plant (5.84), pods/branch (120.40), pods/plant (721.10) were significantly high in treatments FC+VC. There was statistical comparability with FC+PM in case of pods/branch and pods/plant. Further, the seed yield as well as the biological yield in the 2nd year were highest in the treatment FC+VC combination (2308.00 and 9096 kg ha^{-1} respectively).

The manurial form FC+VC produced significantly higher percentage of oil content (32.08) in mustard seed than the other form and control.

4.2.2.3 Biofertilizer and/or organic spray

The test weight in the 2nd year (Table 4.06) was the only parameter which showed significant difference between treatment combinations with biofertilzer and /or organic spray. However, the values of branches/plant in both years (6.00 and 5.71), pods/branch in the 1st year (81.28), pods/plant in the 1st year (497.60), test weight in the 1st year (5.55 g), seed yield in the 1st year (2037.00 kg ha^{-1}) and the biological yield in the 1st year (7420.00 kg ha^{-1}) were highest in treatment combinations with PSB+CU. The values of biological yield in the 2nd year (9284.00 kg ha^{-1}) was highest in treatment combination with PSB+Azsp.

Both the treatment consisting of biofertilizers, *viz.*, PSB+CU and PSB+Azsp registered significantly higher seed oil content over control plots (32.06, 32.01 and 30.85% respectively).

4.2.2.4 Interaction of fertilizer levels and manurial forms

Significant difference between treatments as a result of interaction between levels of fertilizer and manurial forms was observed in the 1st year [Table 4.06.1(a)]. The treatment combination 100% RDF with FC+VC registered significantly higher branches /plant (6.47) than the treatment FC+PM alone (5.55). Treatments 33% RDF

alone, with FC+VC and with FC+PM, 100% RDF alone and with FC+PM were statistically at par with the treatment 100% RDF with FC+VC.

Table 4.06.1(a) **Effect of interaction of fertilizer levels and manurial forms on number of branches of mustard (number/plant) at maturity**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	4.81	5.11	5.55	5.16	4.37	5.33	5.33	5.01
F_1	6.37	5.96	6.44	6.26	5.55	5.74	5.26	5.52
F_2	6.44	6.48	5.92	6.28	6.14	6.48	6.59	6.40
Mean	5.87	5.85	5.97		5.35	5.85	5.73	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		0.30	0.60			0.35	0.71	

In the 2nd year treatment combination 100% RDF with FC+PM (6.59) was significantly above treatment combination 33% RDF with FC+VC (5.73). Treatments 100% RDF alone and with FC+VC were comparable. Treatments 33% RDF alone and with FC+VC, FC+PM alone and FC+VC alone were comparable with 100% RDF alone. Further, the treatment combination 33% RDF with FC+PM was on par with 33% RDF with FC+VC.

Table 4.06.1(b) **Effect of interaction of fertilizer levels and manurial forms on number of pod count of mustard (number/branch) at maturity**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	48.37	55.40	50.59	51.45	55.74	99.22	92.77	82.58
F_1	78.70	90.63	72.88	80.74	113.90	122.70	114.00	116.87
F_2	93.59	96.33	99.84	96.59	122.80	139.30	149.90	137.33
Mean	73.55	80.79	74.44		97.48	120.41	118.89	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		11.55	23.18			11.45	22.98	

The treatment 100% RDF with FC+PM registered significantly high pods/plant count (99.84) over treatment 33%RDF with FC+PM (72.88). The 100% RDF with FC+VC (96.33) was comparable with the most effective treatment [Table 4.06.1(b)]. The treatments 33% RDF alone (78.70), with FC+VC (90.63) and with FC+PM (72.88) were statistically at par with treatment 100% RDF alone (93.59).

In the 2nd year treatment combination 100% RDF with FC+PM followed by 100% RDF with FC+VC registered significantly higher count of pods/branch over treatment 100% RDF alone. Treatments 33% RDF alone, with FC+VC and with FC+PM were statistically comparable with the treatment 100% RDF alone.

Table 4.06.1(c) **Effect of interaction of fertilizer levels and manurial forms on pod count of mustard (number/plant) at maturity**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	243.50	287.20	283.20	271.30	252.90	534.20	495.00	427.37
F_1	504.70	550.50	472.40	509.20	631.00	718.30	595.80	648.37
F_2	604.10	621.90	596.80	607.60	752.40	910.90	998.70	887.33
Mean	450.77	486.53	450.80		545.43	721.13	696.50	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		78.56	157.67			86.70	174.01	

The pod count /plant in the 1st year was significantly higher in treatment combination 100% RDF with FC+VC than treatment FC+VC alone [Table 4.06.1(c)]. The treatment combinations 100% RDF alone and with FC+PM, 33% RDF alone, with FC+VC and with FC+PM were statistically comparable with the treatment 100% RDF with FC+VC.

In the 2nd year the treatment combination 100% RDF with FC+PM registered the highest value, followed by the treatment 100% RDF with FC+VC, both of which were significantly higher than in treatment 100% RDF alone (998.70, 910.90 and 752.40 respectively). The treatment combination 33% RDF with FC+VC (718.30) was comparable with the treatment 100% RDF alone.

Table 4.06.1(d) **Effect of interaction of fertilizer levels and manurial forms on test weight of mustard (g) at maturity**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	4.71	4.99	5.19	4.96	4.59	5.13	5.42	5.05
F_1	5.70	5.70	5.79	5.73	5.06	5.15	5.27	5.16
F_2	5.69	5.54	5.66	5.63	5.22	5.25	5.30	5.26
Mean	5.37	5.41	5.55		4.96	5.18	5.33	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.28	0.57			0.04	0.08	

The data pertaining to test weight values revealed that the treatment combination 33% RDF with FC+PM resulted in maximum value (5.79) in the 1st year and was significantly above treatment FC+PM alone (5.19). Treatments 33% RDF alone and with FC+VC, 100% RDF alone and with FC+PM and with FC+VC were statistically comparable with the most effective treatment [Table 4.06.1(d)].

In the 2nd year the treatment 100% RDF alone registered significantly higher test weight value (5.41), and was significantly above 100% RDF with FC+PM. However, the treatments 33% RDF with FC+PM and 100% RDF with FC+VC were statistically at

par with 100% RDF with FC+PM. Further, the treatments 100% RDF alone and 33% RDF with FC+VC were comparable with the treatment 33% RDF with FC+PM.

Table 4.06.1(e) Effect of interaction of fertilizer levels and manurial forms on seed yield (kg ha^{-1}) of mustard at maturity

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	704.50	747.00	789.10	746.87	756.70	1180.00	1298.00	1078.23
F_1	2151.00	2010.00	2382.00	2181.00	2317.00	2376.00	2113.00	2268.67
F_2	3164.00	2947.00	2941.00	3017.33	3645.00	3369.00	3445.00	3486.33
Mean	2006.50	1901.33	2037.37		2239.57	2308.33	2285.33	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		232.60	466.83			277.20	556.34	

In the 1st year the grain yield was significantly higher in treatment 100% RDF alone (3164.00 kg ha^{-1}) than the treatment 33% RDF with FC+PM. The treatments 33% RDF alone and with FC+VC and with FC+PM were statistically comparable with treatment combination 100% RDF with FC+PM [Table 4.06.1(e)].

In the 2nd year also the maximum value was registered by the treatment 100% RDF alone which was significantly higher than 33% RDF with FC+VC. The treatments 100% RDF with FC+PM and with FC+VC were statistically comparable with the most effective treatment. However, the treatments 33% RDF alone and with FC+PM were at par with the combination 33% RDF with FC+VC.

Table 4.06.1(f) Effect of interaction of fertilizer levels and manurial forms on biological yield (kg ha^{-1}) of mustard at maturity

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	2833.00	2685.00	3074.00	2864.00	3678.00	5172.00	5599.00	4816.33
F_1	7537.00	6422.00	6941.00	6966.67	8877.00	9256.00	8672.00	8935.00
F_2	12190.00	10110.00	10190.00	10830.00	14050.00	12860.00	12890.00	13266.67
Mean	7520.00	6405.67	6735.00		8868.33	9096.00	9053.67	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		907.30	1820.95			843.10	1692.10	

The biological yield in the 1st year was significantly higher in treatment 100% RDF alone (12190.00 kg ha^{-1}) than treatment 100% RDF with FC+VC (10110.00 kg ha^{-1}). The treatment 100% RDF with FC+PM was comparable with the most effective treatment. The treatment combinations with 33% RDF level were at par with each other and was significantly superior to the 0 level combinations [Table 4.06.1(f)].

In the 2nd year also the highest value was registered by the treatment 100% RDF alone (14050.00 kg ha^{-1}) which was significantly higher than treatment combination

33% RDF with FC+VC. The treatments 100% RDF with FC+PM and with FC+VC were statistically comparable with the most effective treatment. However, treatment 33% RDF with FC+VC was significantly higher than the treatment FC+PM alone. Treatments 33% RDF alone and with FC+PM were at par with the treatment combination 33% RDF with FC+VC.

Table 4.06.1(g) Effect of interaction of fertilizer levels and manurial forms on oil content of mustard seed (%)

Factors	1998-99			
	C_0	C_1	C_2	Mean
F_0	29.84	32.99	31.80	31.54
F_1	32.69	31.92	32.04	32.22
F_2	31.62	31.34	30.52	31.16
Mean	31.38	32.08	31.45	
		SEd $\pm$	CD(0.05)	
		0.080	0.160	

The interaction between fertilizer levels and manurial forms was not apparent with reference to oil content in seed [Table 4.06.1(g)]. However, third highest value was recorded in treatment combination 33% RDF with FC+PM (32.04%) which in turn was superior to FC+PM alone. The treatment 33% RDF with FC+VC was at par with treatment 33% RDF with FC+PM (31.92 and 32.04% respectively).

4.2.2.5 Interaction effect due to fertilizer and biofertilizer and/or organic spray

Table 4.06.2(a) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on number of branches (number/plant) of mustard at maturity

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	4.92	5.07	5.48	5.16	4.92	5.00	5.11	5.01
F_1	6.44	5.92	6.40	6.26	5.44	5.59	5.52	5.52
F_2	6.00	6.70	6.14	6.28	6.44	6.26	6.51	6.40
Mean	5.79	5.90	6.01		5.60	5.61	5.71	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		0.30	0.60			0.35	0.71	

Significant difference in the count of branches/plant was observed as a result of the interaction between the factors, *viz.*, levels of fertilizer and biofertilizer and/or organic spray [Table 4.06.2(a)]. The treatment combination 100% RDF with PSB+Azsp registered the highest count (6.70), which was significantly higher than the treatment 100% RDF alone. However, the treatments 33% RDF alone and with PSB+CU and 100%RDF with PSB+CU were statistically comparable with the most effective

treatment. Further, the treatments 100% RDF alone and 33% with PSB+Azsp were on par with 33% RDF alone.

In the 2nd year the treatment 100% RDF with PSB+CU recorded the highest value (6.51) followed by 100% RDF alone (6.44) and with PSB+Azsp (6.25). Treatment 33% RDF with PSB+Azsp was comparable with treatment 100% RDF with PSB+Azsp. Further, treatments 33% RDF alone and with PSB+CU, PSB+CU alone and PSB+Azsp alone were on par with treatment 33% RDF with PSB+Azsp.

Table 4.06.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on pod count (number/branch) of mustard at maturity**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	42.40	58.07	53.89	51.45	85.55	74.66	87.52	82.58
F_1	82.14	68.85	91.22	80.74	129.20	108.90	112.60	116.90
F_2	97.29	93.74	98.73	96.59	130.60	145.00	136.40	137.33
Mean	73.94	73.55	81.28		115.12	109.52	112.17	
		SEd ± 11.55	CD(0.05) 23.18			SEd ± 11.45	CD(0.05) 22.98	

The number of pods per branch in the 1st year was significantly higher in treatment 100% RDF with PSB+CU (98.73) than treatment PSB+Azsp alone (58.07). However, treatments 100% RDF alone (97.29) and with PSB+Azsp (93.74), 33% RDF alone (82.14) and with PSB+CU (91.22) were statistically at par with the most effective treatment combination [Table 4.06.2(b)].

In the 2nd year the treatment 100% RDF with PSB+Azsp recorded significantly higher pods/branch count (145) than treatment 33% RDF with PSB+CU. Treatments 100% RDF alone and with PSB+CU and 33% RDF alone were comparable with the treatment 100% RDF witrh PSB+Azsp. However, treatments 33% RDF with PSB+CU and with PSB+Azsp, and PSB+CU alone were on par with 100% RDF alone.

In the 1st year the treatment combination 100% RDF with PSB+Azsp recorded significantly higher values of pod count per plant than the treatment 33% RDF alone (619.70 and 530.40 respectively). The treatments 100% RDF alone and with PSB+CU and 33% RDF with PSB+CU (596.50, 606.60 and 588.40 respectively) were statistically comparable with the most effective treatment combination, *viz.*, 100% RDF with PSB+Azsp[Table 4.06.2(c)].

Table 4.06.2(c) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on pod count (number/plant) of mustard at maturity**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	219.70	296.30	297.90	271.30	440.30	381.40	460.30	427.33
F_1	530.40	408.90	588.40	509.23	718.20	608.50	618.50	648.40
F_2	596.50	619.70	606.60	607.60	845.70	918.70	897.70	887.37
Mean	448.87	441.63	497.63		668.07	636.20	658.83	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		78.56	157.67			86.70	174.01	

In the 2[nd] year the count of pods/plant was maximum in the treatment combination of 100% RDF with PSB+Azsp which was significantly higher than the treatment 33% RDF alone. Treatment 100% RDF alone and with PSB+CU were statistically comparable. However, the treatment 33% RDF with PSB+CU and PSB+Azsp registered a comparable figure as with treatment 33% RDF alone.

Table 4.06.2(d) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on test weight (g) of mustard at maturity**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	4.68	5.10	5.11	4.96	4.81	5.20	5.13	5.05
F_1	5.27	5.87	6.06	5.73	5.18	5.26	5.04	5.16
F_2	5.71	5.67	5.51	5.63	5.32	5.32	5.13	5.26
Mean	5.22	5.55	5.56		5.10	5.26	5.10	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.28	0.57			0.04	0.08	

The data on test weight as a result of interaction between fertilizer levels and biofertilizer and/or organic spray revealed that the treatment combination 33% RDF with PSB+CU was significantly above treatment 33% RDF alone [Table 4.06.2(d)]. The treatments 33% RDF with PSB+Azsp, 100% RDF alone, with PSB+Azsp and with PSB+CU were statistically comparable with the most effective treatment. However, the treatment 33% RDF alone was on par with treatment 100% RDF alone.

In the 2[nd] year the two treatments 100% RDF alone and with PSB+Azsp were equally significant in producing higher test weight values (5.32 g) and treatment combination 33% RDF with PSB+Azsp was on par with these. Further, the treatments 33% RDF alone and PSB+Azsp alone were comparable with the treatment 33% RDF with PSB+Azsp combination.

Table 4.06.2(e) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on seed yield (kg ha^{-1}) of mustard at maturity**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	718.70	632.90	889.00	746.87	946.70	1159.00	1129.00	1078.23
F_1	2299.00	2139.00	2105.00	2181.00	2261.00	2308.00	2238.00	2269.00
F_2	2974.00	2961.00	3117.00	3017.33	3339.00	3730.00	3389.00	3486.00
Mean	1997.23	1910.97	2037.00		2182.23	2399.00	2252.00	
		SEd ±	CD(0.05)			SEd ±	CD(0 05)	
		232.60	466.83			277.20	556.34	

In the 1st year the seed yield was significantly influenced by the interaction effect and the treatment combination 100% RDF with PSB+CU registered the highest value (3117.00 kg ha^{-1}). Treatments 100% RDF alone and with PSB+Azsp were comparable with the treatment with highest productivity [Table 4.06.2(e)]. The treatment combinations 33% alone, with PSB+Azsp and with PSB+CU were on par with each other and significantly superior to the 0 level fertilizer combination.

In the 2nd year the maximum productivity was registered in treatment combination 100% RDF with PSB+Azsp (3730.00 kg ha^{-1}) and was significantly above the 33% RDF level combination. The treatments 100% RDF alone (3339.00 kg ha^{-1}) and with PSB+CU (3389.00 kg ha^{-1}) were statistically at par with the most effective treatment. However, the 33% RDF level combination, which ranged from 2238.00 to 2308.00 kg ha^{-1}, was significantly superior to the 0 level combinations.

Table 4.06.2(f) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on biological yield (kg ha^{-1}) of mustard at maturity**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	2778.00	2648.00	3167.00	2864.33	4874.00	5001.00	4574.00	4816.33
F_1	7089.00	7052.00	6759.00	6966.67	8801.00	9084.00	8919.00	8934.67
F_2	10370.00	9778.00	12330.00	10826.00	13120.00	13770.00	12910.00	13266.67
Mean	6745.67	6492.67	7418.67		8931.67	9285.00	8801.00	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		907.30	1820.95			843.10	1692.10	

The biological yield was highly significant in treatment 100% RDF with PSB+CU over all other treatments [Table 4.06.2(f)]. The treatments 100% RDF alone and with PSB+Azsp were on par with each other and significant over the 33% RDF level combinations. However, the treatments 33% RDF alone, with PSB+Azsp and with PSB+CU (7089.00, 7052.00 and 6759.00 kg ha^{-1}respectively) were statistically comparable among each other and superior to the 0 level combinations.

In the 2nd year almost similar trend was observed, and the treatment 100% RDF with PSB+Azsp (13770.00 kg ha^{-1}) obtained a value significantly higher than the treatment combination 33% RDF with PSB+Azsp (9084.00 kg ha^{-1}). Treatments 100% RDF alone (13120.00 kg ha^{-1}) and with PSB+CU (12910.00 kg ha^{-1}) were comparable with the best combination. Further, the treatments 33% RDF alone and with PSB+CU (8801.00 and 8919.00 kg ha^{-1} respectively) were comparable with each other and superior to the 0 level RDF combinations.

Table 4.06.2(g) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on oil content of mustard seed (%)

Factors	1998-99			
	B_0	B_1	B_2	Mean
F_0	30.98	32.19	31.46	31.54
F_1	30.92	32.67	33.06	32.22
F_2	30.65	31.16	31.66	31.16
Mean	30.85	32.01	32.06	
		SEd ±	CD(0.05)	
		0.080	0.160	

Interactive effect of fertilizer levels and biofertilizer and/or organic spray produced significant oil content [Table 4.06.2(g)] in treatment combination 33% RDF with PSB+CU over treatment combination 33% RDF with PSB+Azsp, which was in turn superior to PSB+Azsp alone (33.06, 32.67 and 32.19% respectively).

4.2.2.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

Table 4.06.3(a) Effect of interaction of manurial forms and biofertilizer and/or organic spray on number of branches (number/plant) of mustard at maturity

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	5.18	6.29	6.14	5.87	5.03	5.40	5.63	5.35
C_1	6.18	5.59	5.77	5.85	6.22	5.59	5.74	5.85
C_2	6.00	5.81	6.11	5.97	5.55	5.85	5.77	5.73
Mean	5.79	5.90	6.01		5.60	5.61	5.71	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.30	0.60			0.35	0.71	

In the 1st year the interaction between the forms of manure and biofertilizer and/or organic spray resulted in variation between the number of branches per plant in mustard crop of the system [Table 4.06.3(a)]. The treatment PSB+Azsp alone recorded the maximum number (6.29) and was significantly above treatment combination FC+VC with PSB+Azsp (5.59). Treatments FC+VC alone, and with PSB+CU,

PSB+CU alone, FC+PM alone, with PSB+CU and with PSB+Azsp were statistically comparable with the most effective treatment. Further, the treatment combination FC+VC with PSB+Azsp was also comparable with treatment FC+VC alone (6.18).

In the 2nd year also somewhat similar trend was observed and the treatment FC+VC alone secured the highest number of branch count/plant (6.22) which was significantly above treatment PSB+Azsp (5.40). The treatment FC+PM alone, with PSB+Azsp and with PSB+CU, FC+VC with PSB+CU and with PSB+Azsp combinations and PSB+CU alone were at par with treatment FC+VC alone. However, the treatment PSB+Azsp alone was statistically comparable with the treatment combination FC+PM with PSB+Azsp (5.85).

Table 4.06.3(b) Effect of interaction of manurial forms and biofertilizer and/or organic spray on pod count (number/branch) of mustard at maturity

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	67.03	79.44	74.18	73.55	85.51	102.40	104.50	97.47
C_1	84.74	65.14	92.48	80.79	133.10	114.10	114.00	120.40
C_2	70.07	76.07	77.17	74.44	126.70	112.10	117.90	118.90
Mean	73.95	73.55	81.28		115.10	109.53	112.13	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		11.55	23.18			11.45	22.98	

The data consisting of the pods/branch revealed that the most effective treatment combination was FC+VC with PSB+CU (92.48), which was significantly above control (67.03). However, all other treatments, except treatment combination FC+VC with PSB+Azsp were statistically comparable with the most effective treatment combination [Table 4.06.3(b)].

In the 2nd year the treatment FC+VC alone obtained the maximum number of pods/branch (133.10) and was significantly above the treatment PSB+CU alone (104.50). However, the treatments FC+PM alone, with PSB+CU and with PSB+Azsp, FC+VC with PSB+Azsp and with PSB+CU were at par with the most effective treatment. Further, the treatment PSB+Azsp alone (102.40) was statistically at par with the treatment FC+PM with PSB+CU combination (117.90).

In the 1st year [Table 4.06.3 (c)] the treatment FC+VC alone (544.90) registered significantly higher value than control (379.30). All other treatments, except FC+VC with PSB+Azsp were statistically comparable with the most effective treatment.

Table 4.06.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on pod count (number/plant) of mustard at maturity**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	379.30	504.60	468.40	450.77	465.10	568.10	603.00	545.40
C_1	544.90	372.70	542.00	486.53	833.30	655.50	674.50	721.10
C_2	422.30	447.60	482.40	450.77	705.80	684.90	698.90	696.53
Mean	448.83	441.63	497.60		668.07	636.17	658.80	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		78.56	157.67			86.70	174.01	

In the 2nd year also the treatment FC+VC alone (833.30) proved to be most effective in producing the highest number of pods/plant, which was significantly above the treatment FC+VC PSB+Azsp (655.50). The treatments FC+PM alone, with PSB+CU and with PSB+Azsp and FC+VC with PSB+Azsp were comparable with the most effective treatment. However, the treatments FC+VC with PSB+Azsp and PSB+CU alone (603.00) were statistically at par with treatment FC+PM alone (705.80).

Table 4.06.3(d) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on test weight (g) of mustard at maturity**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	4.68	5.86	5.57	5.37	4.76	5.02	5.09	4.96
C_1	5.35	5.53	5.36	5.41	5.22	5.20	5.12	5.18
C_2	5.64	5.26	5.75	5.55	5.33	5.56	5.10	5.33
Mean	5.22	5.55	5.56		5.10	5.26	5.10	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.28	0.57			0.04	0.08	

In the 1st year the test weight value was recorded maximum in treatment PSB+Azsp (5.85 g) and was significantly above the treatment combination FC+PM with PSB+Azsp (5.26 g). The treatments FC+PM alone and with PSB+CU, PSB+CU alone, FC+VC alone, with PSB+Azsp and with PSB+CU were at par with the most effective treatment [Table 4.06.3(d)]. However, the treatment combination FC+PM with PSB+Azsp was statistically comparable with treatment combination FC+PM with PSB+CU (5.75 g).

In the 2nd year however, the treatment combination FC+PM with PSB+Azsp (5.56 g) was markedly significant above the treatments FC+PM alone (5.33 g), which in turn registered significantly higher value than FC+VC alone (5.22 g). The treatment FC+VC with PSB+Azsp (5.20 g) was comparable with the treatment FC+VC alone and these were superior to treatment FC+VC with PSB+CU (5.12 g). However, the

treatments PSB+CU alone (5.09 g) and with FC+PM (5.10 g) were statistically comparable with treatment combination FC+VC with PSB+CU.

Table 4.06.3(e) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on seed yield (kg ha^{-1}) of mustard at maturity**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	1882.00	2051.00	2086.00	2006.33	2101.00	2397.00	2222.00	2240.00
C_1	2051.00	1792.00	1861.00	1901.33	2505.00	2459.00	1961.00	2308.33
C_2	2059.00	1889.00	2164.00	2037.33	1941.00	2341.00	2573.00	2285.00
Mean	1997.33	1910.67	2037.00		2182.33	2399.00	2252.00	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		232.60	466.83			277.20	556.34	

There was no perceivable difference between the seed yield values of different treatments as a result of the intereaction of manurial forms and biofertilizer and/or organic spray [Table 4.06.3(e)]. However, on perusal of the data it is apparent that the maximum yield was obtained by the treatment combination FC+PM with PSB+CU followed by PSB+CU alone, FC+PM alone, FC+VC alone and PSB+Azsp alone, all of which were above the 20 quintal mark (2164.00, 2086.00,2059.00, 2051.00 and 2051.00 kg ha^{-1} respectively).

In the 2nd year also the maximum figures were registered by the treatment FC+PM with PSB+CU (2573.00 kg ha^{-1}) which was significantly above treatment combination FC+VC with PSB+CU (1961.00 kg ha^{-1}). The treatments FC+VC alone and with PSB+Azsp, PSB+Azsp alone, FC+PM with PSB+Azsp and PSB+CU alone were statistically par with the most effective treatment (2505.00, 2459.00, 2397.00, 2341.00 and 2222.00 kg ha^{-1}).

Table 4.06.3(f) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on biological yield (kg ha^{-1}) of mustard at maturity**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	6852.00	7241.00	8463.00	7518.67	8322.00	9354.00	8931.00	8869.00
C_1	7181.00	5944.00	6093.00	6406.00	9930.00	9359.00	7998.00	9095.67
C_2	6204.00	6293.00	7704.00	6733.67	8542.00	9138.00	9475.00	9051.67
Mean	6745.67	6492.67	7420.00		8931.33	9283.67	8801.33	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		907.30	1820.95			843.10	1692.10	

The biological yield in the 1st year was significantly higher in treatment PSB+CU alone (8463.00 kg ha^{-1}) than treatment FC+PM with PSB+Azsp (6293.00 kg ha^{-1}). Treatments FC+PM with PSB+CU, PSB+Azsp alone, FC+VC alone, were

statistically comparable with the treatment with the highest value [Table 4.06.3(f)]. However, all the rest of the treatments, except FC+VC with PSB+Azsp were on par with the treatment FC+PM with PSB+CU (7704.00 kg ha^{-1}).

In the 2nd year the maximum biological yield was recorded in treatment FC+VC alone (9930.00 kg ha^{-1}) which was significantly above treatment FC+VC with PSB+CU (7998.00 kg ha^{-1}). All other treatments were statistically comparable with the most effective treatment.

Table 4.06.3(g) Effect of interaction of manurial forms and biofertilizer and/or organic spray on oil content of mustard seed (%)

Factors	1998-99			
	B_0	B_1	B_2	Mean
C_0	31.49	31.66	31.00	31.38
C_1	30.87	32.82	32.57	32.09
C_2	30.20	31.54	32.62	31.45
Mean	30.85	32.01	32.06	
		SEd $\pm$	CD(0.05)	
		0.080	0.160	

The treatment combination FC+VC with PSB+Azsp registered significantly higher oil content in seed [Table 4.06.3(g)] over treatment FC+PM with PSB+CU, which in turn was superior to PSB+Azsp (32.82, 32.62 and 31.66% respectively). However, the treatment FC+VC with PSB+CU (32.57%) combination was statistically at par with the second best treatment.

4.2.3 Post-cropping soil status

4.2.3.1 Fertilizer levels

The soil EC_{25} in the 2nd year and available potassium in the 1st year were the parameters significantly effected as a result of the different fertilizer levels and the two levels 100% as well as 33% RDF were comparable (Table 4.07). Significantly lower values were recorded in the above two levels (0.136 and 0.131 dS m^{-1} respectively) than in the 0 level of RDF. Similarly, the available potassium in the 1st year in these two RDF levels were 551.40 and 492.10 kg ha^{-1} respectively.

4.2.3.2 Manurial forms

Significant difference between treatments was apparent due to the factor, *viz.*, manurial forms on the EC_{25} in both the years, organic carbon (%) and available potassium (kg ha^{-1}) in the 1st year (Table 4.07). EC_{25} was significantly lower in

treatment FC+PM in both the years (0.415 and 0.135 respectively). The values registered by the treatment FC+VC were statistically at par with the FC+PM treatment in both the years (0.429 and 0.139 respectively).

The organic carbon (%) as well as the available potassium (kg ha^{-1}) were significantly higher in the treatment FC+VC (0.663 and 540.50 respectively) and the treatment FC+PM recorded statistically comparable values (0.640 and 523.30 respectively).

4.2.3.3 Biofertilizer and/or organic spray

There was no apparent significant difference in the post-cropping soil status as a result of the biofertilizer and/or organic spray, except in the 2nd year when the EC_{25} was 0.133 dS m^{-1} in the treatment combination PSB+CU (Table 4.07). The figures obtained by the treatment combination PSB+Azsp were statistically comparable (0.144 dS m^{-1}). Further, the value of EC_{25} was minimum in the treatment FC+PM in the 1st year (0.427 dS m^{-1}), the percentage organic carbon was maximum in the treatment FC+VC (0.356) in the 1st year and in treatment FC+PM (0.656) in the 2nd year. The available phoshorus and potassium in the 1st year was highest in the treatment combination with FC+PM (20.63 and 533.80 kg ha^{-1}) and in the 2nd year these were maximum in 0 level RDF combinations and FC+VC combinations (26.00 and 407.70 kg ha^{-1} respectively).

Table 4.07 **Effect of mustard cropping on the Physico-chemical properties of the soil**

Factors	pH		EC_{25} ($dS\ m^{-1}$)		Organic Carbon (%)		AvailableP_2O_5 ($kg\ ha^{-1}$)		Available K_2O ($kg\ ha^{-1}$)	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Levels of Fertilizers (F):										
F_0	7.77	7.47	0.459	0.167	0.275	0.565	13.89	25.48	486.60	374.40
F_1	7.70	7.44	0.438	0.131	0.354	0.625	15.70	22.19	492.10	425.10
F_2	7.66	7.45	0.441	0.136	0.347	0.639	22.96	27.70	551.40	394.40
	NS	NS	NS	*	NS	NS	NS	NS	*	NS
Forms of manure (C):										
C_0	7.70	7.49	0.494	0.159	0.303	0.526	17.78	26.04	466.30	387.90
C_1	7.71	7.44	0.429	0.139	0.343	0.663	16.59	26.30	540.50	406.40
C_2	7.71	7.43	0.415	0.135	0.331	0.640	18.19	23.04	523.30	399.60
	NS	NS	*	*	NS	*	NS	NS	*	NS
Biofertilizers and/or organic spray (B):										
B_0	7.72	7.49	0.465	0.156	0.301	0.573	16.04	26.00	498.90	382.70
B_1	7.72	7.43	0.447	0.144	0.356	0.602	15.89	24.70	497.40	407.70
B_2	7.69	7.44	0.427	0.133	0.319	0.656	20.63	24.67	533.80	403.40
	NS	NS	NS	*	NS	NS	NS	NS	NS	NS
SEd ±	0.0471	0.0371	0.0327	0.0085	0.0417	0.0423	0.5228	4.084	30.683	21.685
CD(0.05)	-	-	0.0658	0.0172	-	0.0849	-	-	61.569	-
FxC FxB CxB:										
SEd ±	0.0815	0.0583	0.0568	0.0148	0.0723	0.0732	9.055	7.075	53.14	37.87
CD(0.05)	0.1637	0.1171	0.1140	0.0298	0.0145	0.147	18.170	14.199	106.65	76.06

*Significant at P = 0.05 NS = non-significant

4.2.3.4 Interaction effect due to fertilizer levels and manurial forms

Table 4.07.1(a) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (mustard) status of soil EC_{25} ($dS\ m^{-1}$)**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.559	0.412	0.408	0.460	0.214	0.131	0.156	0.167
F_1	0.452	0.423	0.441	0.439	0.128	0.142	0.124	0.131
F_2	0.473	0.452	0.398	0.441	0.137	0.144	0.128	0.136
Mean	0.495	0.429	0.416		0.160	0.139	0.136	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.057	0.114			0.015	0.030	

The soil data pertaining to EC_{25} in the 1st year showed that the treatment 100% RDF with FC+PM recorded the least value (0.398) and all other treatments were at par with the best treatment [Table 4.07.1(a)]. The maximum figure was recorded by control (0.559).

In the 2nd year the least figures were registered by the treatment 33% RDF with FC+PM (0.124) and all other treatments, except FC+PM alone (0.156), were statistically at par with the most effective treatment. The maximum value was recorded by control (0.214).

In the 1st year the percentage organic carbon in the soil was maximum in treatment combination 33% RDF with FC+PM (0.468) and was significantly above the treatment combination 33% RDF with FC+VC (0.266). The treatments 100% RDF alone and with FC+VC, FC+VC alone, and 33% RDF alone were comparable with the treatment 33% RDF with FC+PM [Table 4.07.1(b)].

Table 4.07.1(b) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (mustard) status of soil organic carbon (%)**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.210	0.354	0.262	0.276	0.433	0.642	0.621	0.566
F_1	0.331	0.266	0.468	0.355	0.564	0.714	0.599	0.626
F_2	0.368	0.411	0.264	0.348	0.582	0.634	0.702	0.640
Mean	0.303	0.344	0.331		0.527	0.664	0.641	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.072	0.145			0.073	0.147	

In the 2nd year the highest figure was recorded in treatment 33% RDF with FC+VC combination (0.714) and was markedly higher than treatment 33% RDF alone (0.564). The treatments 100% RDF alone, with FC+PM and with FC+VC, FC+VC

alone, FC+PM alone and 33% RDF with FC+PM were statistically at par with the most effective treatment. However, there was comparability between the treatment 33% RDF alone (0.564) and treatment combination 100% RDF with FC+PM.

Table 4.07.1(c) Effect of interaction of fertilizer levels and manurial forms on post-cropping (mustard) status of available P_2O_5 (kg ha^{-1}) of soil

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	16.44	9.78	15.44	13.89	24.56	28.22	23.67	25.48
F_1	11.89	19.56	15.67	15.71	27.78	20.33	18.44	22.18
F_2	25.00	20.44	23.44	22.96	25.78	30.33	27.00	27.70
Mean	17.78	16.59	18.18		26.04	26.29	23.04	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		9.06	18.17			7.08	14.20	

In the 1st year there was no apparent difference between the treatments with regard to the post-cropping soil status of available phosphorus as a result of interaction between levels of fertlizer and manurial forms [Table 4.07.1(c)]. However, the maximum value was registered by the treatment 100% RDF alone, followed by 100% RDF with FC+PM and with FC+VC and treatment combination 33% RDF with FC+VC (25.00, 23.44, 20.44 and 19.56 kg ha^{-1} respectively).

Similarly, in the 2nd year also significant difference was not perceivable statistically. Nevertheless, the maximum figure was registered by treatment combination 100% RDF with FC+VC followed by FC+VC alone and 33% RDF alone (30.33, 28.22 and 27.78 kg ha^{-1} respectively).

Table 4.07.1(d) Effect of interaction of fertilizer levels and manurial forms on post-cropping (mustard) status of available K_2O (kg ha^{-1}) of soil

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	443.60	508.10	508.10	486.60	325.80	416.80	380.60	374.40
F_1	454.30	510.20	511.80	492.10	432.40	361.30	481.40	425.03
F_2	501.00	603.20	549.90	551.37	405.30	441.00	336.90	394.40
Mean	466.30	540.50	523.27		387.83	406.37	399.63	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		53.14	106.65			37.87	76.01	

In the 1st year the available potassium of the post-cropping soil sample showed significantly higher value in treament 100% RDF with FC+VC combination than 100% RDF alone (603.20 and 501.00 kg ha^{-1} respectively). The treatments 100% RDF with FC+PM, 33% RDF with FC+PM and with FC+VC, FC+PM alone and FC+VC alone were statistically comparable with the most effective treatment [Table 4.07.1(d)].

In the 2nd year the treatment 33% RDF with FC+PM combination registered the maximum value which was significant above treatment FC+PM alone (481.40 and 380.60 kg ha^{-1}). The treatments 100% RDF alone and with FC+VC, 33% RDF alone and FC+VC alone were comparable with the most effective treatment.

4.2.3.5 Interaction effect of fertilizer levels and biofertilizer and/or organic spray

Table 4.07.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (mustard) status of soil EC_{25} (dS m^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.497	0.408	0.474	0.460	0.193	0.166	0.142	0.167
F_1	0.461	0.496	0.360	0.439	0.127	0.137	0.131	0.132
F_2	0.438	0.438	0.448	0.441	0.150	0.132	0.127	0.136
Mean	0.465	0.447	0.427		0.157	0.145	0.133	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.057	0.114			0.015	0.030	

The EC_{25} in the 1st year was significantly lower in treatment 33% RDF with PSB+CU (0.360) combination than the treatment 33% RDF with PSB+Azsp (0.496). All treatments were statistically comparable with the most effective treatment [Table 4.07.2(a)].

In the 2nd year the treatment 33% RDF registered significantly lower values of EC_{25} (0.127) than the treatment PSB+Azsp (0.166). The treatments 100% RDF alone, with PSB+CU and with PSB+Azsp, 33% RDF with PSB+CU and with PSB+Azsp and PSB+CU were statistically at par with the most effective treatment. However, treatment PSB+Azsp was comparable with treatment combination 33% RDF with PSB+Azsp.

Table 4.07.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (mustard) status of soil organic carbon (%)**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.258	0.327	0.242	0.276	0.481	0.577	0.639	0.566
F_1	0.303	0.398	0.363	0.355	0.649	0.572	0.657	0.626
F_2	0.344	0.346	0.353	0.348	0.590	0.657	0.672	0.640
Mean	0.302	0.357	0.320		0.573	0.602	0.656	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.072	0.145			0.073	0.147	

The percentage organic carbon of the post-cropping soil in the 1st year showed maximum analysis of 0.398 in the treatment combination 33% with PSB+Azsp, which

was significantly above the treatment PSB+CU alone (0.242). However, all other treatments were statistically at par with the former treatment combination [Table 4.07.2(b)].

Somewhat similar trend was observed in the 2nd year, and the maximum value was recorded in treatment combination 100% RDF with PSB+CU (0.672), which was significantly above control (0.481). All other treatments were statistically comparable with the most effective treatment.

Table 4.07.2(c) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (mustard) status of available P_2O_5 (kg ha^{-1}) of soil

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	10.33	20.78	10.56	13.89	19.56	33	23.56	25.48
F_1	14.78	10.00	22.33	15.70	24.00	19.00	23.56	22.19
F_2	23.00	16.89	29.00	22.96	34.44	21.78	26.89	27.70
Mean	16.04	15.89	20.63		26.00	24.70	24.67	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		9.06	18.17			7.08	14.20	

In the 1st year the treatment combination 100% RDF with PSB+CU registered the highest value of 29.00 kg ha^{-1} available phosphorus in the post-cropped soil, which was significantly above treatment PSB+CU alone (10.56). The treatments 100% RDF alone and with FC+Azsp, 33% RDF alone and with PSB+CU, PSB+Azsp alone showed statistical comparability with the most effective treatment [Table 4.07.2(c)].

In the 2nd year the maximum value was recorded in treatment 100% RDF alone (34.44) and was significantly above control (19.56). All treatments except 33% RDF with PSB+Azsp were statistically at par with the treatment with the highest figures.

Table 4.07.2(d) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (mustard) status of available K_2O (kg ha^{-1}) of soil

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	411.00	542.70	506.10	486.60	326.60	416.00	380.60	374.40
F_1	493.40	455.40	527.40	492.07	439.90	406.70	428.70	425.10
F_2	592.10	494.20	567.80	551.37	381.70	400.40	401.10	394.40
Mean	498.83	497.43	533.77		382.73	407.70	403.47	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		53.14	106.65			37.87	76.01	

The available potassium was highest in the soil of the plots treated with 100% RDF followed by treatments 100% RDF with PSB+CU, PSB+Azsp alone, 33% RDF with PSB+CU, PSB+CU alone, 100% RDF with PSB+Azsp and 33% RDF alone

(592.10, 567.80, 542.70, 527.40, 506.10, 494.20 and 493.40 kg ha^{-1} respectively), all of which were statistically comparable and significantly above the treatment 33% RDF with PSB+Azsp alone (455.40 kg ha^{-1}) [Table 4.07.2(d)].

In the 2nd year the maximum value was registered by the treatment 33% RDF alone and was significantly above control (439.90 and 326.60 kg ha^{-1} respectively). All other treatments were statistically at par with the most effective treatment.

4.2.3.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

Table 4.07.3(a) Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (mustard) status of soil EC_{25} (dS m^{-1})

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.610	0.431	0.443	0.495	0.187	0.148	0.144	0.160
C_1	0.416	0.496	0.377	0.429	0.151	0.134	0.132	0.139
C_2	0.370	0.414	0.462	0.416	0.132	0.152	0.123	0.136
Mean	0.465	0.447	0.427		0.157	0.145	0.133	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.057	0.114			0.015	0.030	

The data on EC_{25} in the 1st year revealed that the treatment FC+PM resulted in the lowest figure and was significantly over the treatment combination FC+VC with PSB+Azsp (0.370 and 0.496 dS m^{-1} respectively). All other treatments were at par with the treatment with the least figures [Table 4.07.3(a)]. The control plot registered a value of 0.610 dS m^{-1}.

In the 2nd year the least figures were recorded in soil sample of plots treated with FC+PM with PSB+CU combination which was significantly lower than the control plot (0.123 and 0.187 dS m^{-1} respectively). All other treatments were statistically comparable with the most effective treatment.

Table 4.07.3(b) Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (mustard) status of soil organic carbon (%)

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.241	0.352	0.316	0.303	0.417	0.532	0.631	0.527
C_1	0.347	0.322	0.362	0.344	0.611	0.704	0.676	0.664
C_2	0.318	0.396	0.281	0.332	0.692	0.569	0.661	0.641
Mean	0.302	0.357	0.320		0.573	0.602	0.656	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.072	0.145			0.073	0.147	

The percentage organic carbon in the 1st year was significantly high in treatment FC+PM with PSB+Azsp (0.396) combination than in control (0.241) and all other treatments were statistically comparable with the former [Table 4.07.3(b)].

In the 2nd year the treatment combination FC+VC with PSB+Azsp registered the maximum value (0.704) which was significantly above treatment PSB+Azsp (0.532). All other treatments were statistically at par with the most effective treatment.

Table 4.07.3(c) Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (mustard) status of available P_2O_5 (kg ha^{-1}) of soil

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	16.78	18.33	18.22	17.78	22.22	27.67	28.22	26.04
C_1	14.89	8.44	26.44	16.59	30.33	28.78	19.78	26.30
C_2	16.44	20.89	17.22	18.18	25.44	17.67	26.00	23.04
Mean	16.04	15.89	20.63		26.00	24.71	24.67	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		9.06	18.17			7.08	14.20	

The data pertaining to the post-cropping soil status did not reveal any perceivable difference between the treatments as a result of interaction between manurial forms and biofertilizer and/or organic spray [Table 4.07.3(c)]. However, the highest figures were registered in the treatment combination FC+VC with PSB+CU, followed by FC+PM with PSB+Azsp, PSB+Azsp alone, PSB+CU alone and treatment combination FC+PM with PSB+CU (26.44, 20.89, 18.33, 18.22 and 17.22 kg ha^{-1} respectively).

In the 2nd year also no apparent difference between the treatments was observed. However, the treatment FC+VC alone recorded the maximum value followed by FC+VC with PSB+Azsp, PSB+CU alone, PSB+Azsp alone, FC+PM with PSB+CU and FC+PM alone (30.33, 28.78, 28.22, 27.67, 26.00 and 25.44 kg ha^{-1} respectively).

Table 4.07.3(d) Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (mustard) status of available K_2O (kg ha^{-1}) of soil

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	440.00	511.40	447.40	466.27	365.90	401.30	396.30	387.83
C_1	560.90	540.90	519.80	540.53	360.40	432.30	426.30	406.33
C_2	495.70	440.00	634.10	523.27	421.80	389.40	387.70	399.63
Mean	498.87	497.43	533.77		382.70	407.67	403.43	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		53.14	106.65			37.87	76.01	

In the 1st year the treatment combination FC+PM with PSB+CU secured the highest value of available potassium which was significantly above the treatment FC+VC with PSB+CU (634.10 and 519.80 kg ha^{-1} respectively). The treatments FC+VC alone (560.90) and with PSB+Azsp (540.90) were statistically comparable with the treatment combination FC+PM with PSB+CU [Table 4.07.3(d)].

However, in the 2nd year there was no significant difference between the treatments. The maximum value was registered in treatment combination FC+VC with PSB+Azsp, followed by FC+VC with PSB+CU, FC+PM alone, PSB+Azsp alone, PSB+CU alone (432.30, 426.30, 421.80, 401.30 and 396.30 kg ha^{-1} respectively).

4.3 Experiment 1: (Soybean – Mustard – Fodder cowpea system) Crop component 3: Fodder Cowpea

4.3.1 Dry matter accumulation

4.3.1.1 Fertilizer levels

Significant difference between treatments was observed as a result of the varying levels of fertilizer on the dry weight values of plants during the successive stages (Table 4.08). At 15 DAS in the 1st year the treatments with 100% RDF level registered the highest value (1.582 g) and treatment 33% RDF was statistically at par with it, whereas in the 2nd year the treatment 33% RDF recorded the maximum value (0.760 g) and here the treatment 100% RDF was comparable with the most effective treatment.

At 30 and 45 DAS in both the years the treatment with 100% RDF resulted in the highest values (5.614 and 15.25 g in 1st year and 7.307 and 20.34 g in 2nd year respectively). The treatment 33% RDF was comparable with the most effective treatment during the 1st year at 30 DAS (5.219 g).

Table 4.08 Effect of INM on dry weight of fodder cowpea (g/plant) during 1997-98 and 1998-99

Factors	15 DAS		30 DAS		45 DAS		60 DAS	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Levels of Fertilizers (F):								
F_0	1.188	0.560	2.802	5.391	12.31	15.25	21.13	25.31
F_1	1.403	0.760	5.219	5.919	12.64	16.48	25.66	28.43
F_2	1.582	0.716	5.614	7.307	15.25	20.34	22.58	30.24
	*	*	*	*	*	*	NS	*
Forms of manure (C):								
C_0	1.288	0.600	4.276	5.941	11.65	16.28	21.88	26.01
C_1	1.416	0.652	4.638	6.123	15.29	18.43	23.95	28.72
C_2	1.469	0.790	4.722	6.552	13.25	17.33	23.53	29.25
	NS	*	NS	NS	*	NS	NS	NS
Biofertilizers and/or organic spray (B):								
B_0	1.399	0.635	4.650	5.762	11.32	16.59	20.03	25.19
B_1	1.369	0.732	4.301	6.611	14.45	17.59	24.41	29.59
B_2	1.405	0.673	4.685	6.244	14.43	17.86	24.93	29.20
	NS	NS	NS	NS	*	NS	NS	*
SEd ±	0.1346	0.0711	0.4548	0.5632	1.2934	1.5773	2.4102	1.0037
CD(0.05)	0.2702	0.1427	0.9126	1.1300	2.5666	3.2650	-	2.0141
FxC FxB CxB:								
SEd ±	0.2332	0.1232	0.7879	0.9760	2.2150	2.7320	4.1750	1.7380
CD(0.05)	0.4680	0.2470	1.5810	1.9580	4.4450	5.4830	8.3792	3.4881

*Significant at P = 0.05 NS = non-significant

Significant differences between treatments were not seen at 60 DAS in the 1st year. However, the treatment 33% RDF recorded the highest value followed by the 100% RDF (25.66 and 22.58 g respectively). In the 2nd year treatment 100% RDF

registered significantly higher value (30.24 g) than the treatment with 0 level RDF. The 33% RDF level was statistically comparable with the most effective treatment (28.43 g).

4.3.1.2 Manurial forms

Significant variations between treatments as a result of different manurial forms were noticed only at 45 DAS in the 1st year and at 15 and 60 DAS in the 2nd year (Table 4.08). However, the maximum dry weight values during the successive stages were obtained by either of the treaments FC+VC or FC+PM.

The maximum values at 15 DAS in the 1st year were obtained by treatment FC+PM (1.469 g) followed closely by the FC+VC combination with 1.416 g. In the 2nd year the highest value was registered by the treatment FC+PM (0.790 g) which was statistically above the control. The treatment FC+VC (0.652 g) was comparable to the FC+PM treatment.

At the 30 DAS in both the years no apparent significant difference between treatments were observed. Nevertheless, the maximum figures were recorded by the treatment FC+PM followed by FC+VC in both years (4.722 and 4.638 in the 1st year and 6.552 and 6.123 g in the 2nd year respectively).

At 45 DAS in both the years the treatment FC+VC registered the highest figures (15.29 and 18.43 g respectively). In the 1st year the value was significantly above the control (11.65 g) and the value recorded by treatment FC+PM (13.25 g) was statistically comparable.

The data at 60 DAS in the 1st year was not significant but the maximum value was obtained in the treatment FC+VC (23.95 g). In the 2nd year however, the highest value was registered by the treatment FC+PM (29.25 g) which was significantly above the control plot. The value obtained by treatment FC+VC (28.72 g) was statistically at par with the most effective treatment.

4.3.1.3 Biofertilizer and/or organic spray

Significant differences in per plant dry weight values as a result of biofertilizer and/or organic spray were noticed at 45 DAS in the 1st year and at 60 DAS in the 2nd year (Table 4.08). However, the data recorded at other stages in both the years showed higher values in either of the treatment combinations, i.e., PSB+Rhz or PSB+CU.

At 15 and 30 DAS in the 1st year the treatment PSB+CU registered higher values of 1.405 and 4.685 g respectively, whereas in the 2nd year the treatment PSB+Rhz obtained higher figures of 0.732 and 6.611g respectively.

At 45 DAS in the 1st year the treatment PSB+Rhz recorded significantly higher values over the control. However, the treatment PSB+CU was statistically on par with PSB+Rhz combination (14.43 and 14.45 g respectively). In the 2nd year, PSB+CU obtained a higher figure, followed by PSB+Rhz (17.86 and 17.59 g respectively).

In the 1st year, at 60 DAS the treatment PSB+CU with 24.93 g was higher than treatment PSB+Rhz with 24.41 g. However, in the 2nd year PSB+Rhz registered significantly higher value than control and treatment PSB+Rhz was statistically comparable (29.59 and 29.20 g respectively).

4.3.1.4 Interaction effect of fertilizer levels and manurial forms

Table 4.08.1(a) Effect of interaction of fertilizer levels and manurial forms on dry weight of fodder cowpea (g/plant) at 15 DAS

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.90	1.30	1.36	1.19	0.43	0.55	0.72	0.57
F_1	1.32	1.34	1.55	1.40	0.73	0.75	0.80	0.76
F_2	1.64	1.62	1.49	1.58	0.64	0.66	0.85	0.72
Mean	1.29	1.42	1.47		0.60	0.65	0.79	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		0.23	0.47			0.12	0.25	

The interaction due to fertilizer levels and manurial forms showed significant difference between the different treatments at successive stages during both the years. In the 1st year at 15 DAS [Table 4.08.1(a)] the treatment 100% RDF obtained significantly higher value over control (1.643 and 0.904 g respectively). All other treatment combinations were statistically comparable with treatment 100% RDF.

In the 2nd year, the treatment 100% RDF with FC+PM combination registered significantly higher per plant dry weight values than FC+VC alone (0.849 and 0.549 g respectively). Treatments 33% RDF alone, with FC+PM and with FC+VC, FC+PM alone, 100% RDF alone and with FC+VC were statistically at par with the most effective combination. However, treatment FC+VC was comparable with treatments 33% RDF with FC+VC.

Table 4.08.1(b) **Effect of interaction of fertilizer levels and manurial forms on dry weight of fodder cowpea (g/plant) at 30 DAS**

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	2.39	3.25	2.77	2.80	4.73	5.77	5.67	5.39
F_1	4.83	4.91	5.92	5.22	5.62	6.09	6.05	5.92
F_2	5.62	5.75	5.48	5.61	7.48	6.51	7.93	7.31
Mean	4.28	4.64	4.72		5.94	6.12	6.55	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.79	1.58			0.98	1.96	

At 30 DAS in the 1st year [Table 4.08.1(b)] the treatment combination 33% RDF with FC+PM was significantly higher than treatment FC+VC alone. Treatments 100% RDF alone, with FC+VC and with FC+PM, 33% RDF alone and with FC+VC were statistically comparable with the most effective treatment.

In the 2nd year the treatment combination 100% RDF with FC+PM was significantly higher than FC+VC alone (7.93 and 5.77 g respectively). Treatments 100% RDF alone and with FC+VC, 33% RDF with FC+VC and with FC+PM were statistically at par with the most effective treatment. Further, the treatment 33% RDF alone was on par with 100% RDF alone (5.62 and 7.48 g rspectively).

Table 4.08.1(c) **Effect of interaction of fertilizer levels and manurial forms on dry weight of fodder cowpea (g/plant) at 45 DAS**

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	8.67	15.86	12.39	12.31	11.23	19.10	15.31	15.21
F_1	12.90	12.17	12.83	12.63	17.35	16.70	15.40	16.48
F_2	13.38	17.84	14.52	15.25	20.25	19.49	21.28	20.34
Mean	11.65	15.29	13.25		16.28	18.43	17.33	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		2.22	4.45			2.73	5.48	

In the 1st year at 45 DAS [Table 4.08.1(c)] the treatment combination 100% RDF with FC+VC registered significantly higher values than 100% RDF alone. Treatments FC+VC alone and 100% RDF with FC+PM were statistically at par with the most effective treatment. However, treatment 100% RDF alone was statistically on par with FC+VC alone (13.38 and 15.86 g respectively).

In the 2nd year the treatment combination 100% RDF with FC+PM recorded significantly higher values than treatment 33% RDF with FC+PM (21.28 and 15.40 g). Treatments 100% RDF alone and with FC+VC, FC+VC alone and 33% RDF alone were statistically comparable with the most effective treatment.

Table 4.08.1(d) **Effect of interaction of fertilizer levels and manurial forms on dry weight of fodder cowpea (g/plant) at 60 DAS**

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	14.71	24.22	24.44	21.12	18.50	28.76	28.67	25.31
F_1	25.83	23.94	27.21	25.66	30.27	27.70	27.34	28.44
F_2	25.11	23.69	18.94	22.58	29.28	29.71	31.74	30.24
Mean	21.88	23.95	23.53		26.02	28.72	29.25	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.18	8.38			1.74	3.49	

In the 1st year at 60 DAS [Table 4.08.1(d)] the treatment combination 33% RDF with FC+PM registered significantly high dry weight values than control (27.21 and 14.71 g respectively). All other treatments were statistically comparable to the most effective treatment.

In the 2nd year the treatment combination 100% RDF with FC+PM registered significantly higher values than treatment combination 33% RDF with FC+VC (31.74 and 27.70 g respectively). The treatments 33% RDF alone, 100% RDF alone and with FC+VC, FC+VC alone and FC+PM alone were statistically at par with the 100% RDF with FC+PM. However, treatments 33% RDF with FC+VC and with FC+PM were statistically comparable with the 2nd best treatment, i.e., 33% RDF alone (27.70, 27.34 and 30.27 g respectively).

4.3.1.5 Interaction effect of fertilizer levels and biofertilizer and/or organic spray

Table 4.08.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of fodder cowpea (g/plant) at 15 DAS**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	1.14	1.27	1.16	1.19	0.56	0.61	0.53	0.57
F_1	1.33	1.43	1.45	1.40	0.80	0.81	0.67	0.76
F_2	1.73	1.41	1.61	1.58	0.54	0.78	0.82	0.72
Mean	1.40	1.37	1.41		0.64	0.73	0.67	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.23	0.47			0.12	0.25	

The interaction between the fertilizer levels and biofertilizer and/or organic spray has shown perceivable affect on the plant dry weight values of fodder cowpea in the cropping system [Table 4.08.2(a)]. In the 1st year at 15 DAS treatment 100% RDF alone was significantly higher than PSB+CU alone. Treatments 100% RDF with PSB+CU, with PSB+Rhz, 33% RDF alone, with PSB+CU and with PSB+Rhz and

PSB+Rhz alone were statistically on par with the most effective treatment. However, the treatment PSB+CU was also comparable with 100% RDF with PSB+CU.

In the 2[nd] year the treatment combination 100% RDF with PSB+CU registered significantly higher values than the control plots (0.823 and 0.560 g respectively). The treatments 33% RDF alone, with PSB+Rhz and with PSB+CU and treatment PSB+Rhz alone were statistically at par with the most effective treatment.

Table 4.08.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of fodder cowpea (g/plant) at 30 DAS**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	2.52	3.13	2.76	2.80	4.58	6.78	4.81	5.39
F_1	5.60	4.62	5.44	5.22	5.97	5.81	5.98	5.92
F_2	5.83	5.15	5.86	5.61	6.74	7.24	7.95	7.31
Mean	4.65	4.30	4.69		5.76	6.61	6.24	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.79	1.58			0.98	1.96	

At 30 DAS in the 1[st] year [Table 4.08.2(b)] the treatment 100% RDF with PSB+CU recorded significantly higher values over treatment PSB+Rhz alone (5.86 and 3.13 g). Treatments 100% RDF alone and with PSB+Rhz, 33% RDF alone, with PSB+CU and with PSB+Rhz were statistically on par with the most effective treatment. Further, the treatment PSB+Rhz alone was comparable with treatment combination 33% RDF with PSB+Rhz (3.13 and 4.62 g respectively).

In the 2[nd] year the treatment 100% RDF with PSB+CU registered significantly higher value than treatment 33% RDF with PSB+CU (7.94 and 5.98 g). Treatments 100% RDF alone and with PSB+Rhz, PSB+Rhz alone were statistically comparable with the most effective treatment.

Table 4.08.2(c) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of fodder cowpea (g/plant) at 45 DAS**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	9.11	13.37	14.44	12.31	13.34	16.21	16.08	15.21
F_1	9.98	14.39	13.54	12.64	16.61	18.14	14.70	16.48
F_2	14.87	15.57	15.31	15.25	19.81	18.41	22.79	20.34
Mean	11.32	14.44	14.43		16.59	17.59	17.86	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		2.22	4.45			2.73	5.48	

At 45 DAS in the 1[st] year the treatment 100% RDF with PSB+Rhz recorded significantly higher values than treatment 33% RDF alone (15.57 and 9.97 g

respectively). The treatments 100% RDF alone and with PSB+CU, PSB+CU alone and 33% RDF with PSB+Rhz were statistically at par with the most effective treatment combination [Table 4.08.2(c)].

In the 2nd year, treatment combination 100% RDF with PSB+CU treatment was markedly higher than treatment 100% RDF with PSB+Rhz (22.79 and 18.41 g respectively). Treatment 100% RDF alone was comparable with the most effective treatment (19.81 g).

Table 4.08.2(d) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of fodder cowpea (g/plant) at 60 DAS**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	16.22	20.84	26.31	21.12	21.17	26.86	27.90	25.31
F_1	21.52	31.12	24.33	25.66	26.00	30.94	28.36	28.43
F_2	22.34	21.26	24.14	22.58	28.41	30.98	31.33	30.24
Mean	20.03	24.41	24.93		25.19	29.59	29.20	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.18	8.38			1.74	3.49	

At 60 DAS in the 1st year, treatment 33% RDF with PSB+Rhz combination was significantly more effective than treatment 100% RDF alone in dry matter accumulation (31.12 and 22.34 g respectively). Treatment PSB+CU was statistically at par with the most effective treatment [Table 4.08.2(d)].

In the 2nd year, treatment 100% RDF with PSB+CU combination registered significantly higher values than the treatment PSB+Rhz alone (31.33 and 26.86 g respectively). Treatments 100% RDF alone and with PSB+Rhz, 33% RDF with PSB+Rhz, PSB+CU alone and with 33% RDF were statistically on par with the most effective treatment.

4.3.1.6 Interaction effect of manurial forms and biofertilizer and/or organic spray

Table 4.08.3(a) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of fodder cowpea (g/plant) at 15 DAS**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	1.21	1.23	1.42	1.29	0.48	0.76	0.56	0.60
C_1	1.53	1.41	1.31	1.42	0.65	0.62	0.69	0.65
C_2	1.46	1.46	1.49	1.47	0.78	0.82	0.77	0.79
Mean	1.40	1.37	1.41		0.64	0.73	0.67	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.23	0.47			0.12	0.25	

At 15 DAS in the 1st year, there was no significant difference between the dry weight values of various treatments as a result of the interaction between manurial forms and biofertilizer and/or organic spray [Table 4.08.3(a)]. However, the maximum figures were observed in treatment FC+VC alone followed by FC+PM combinations (1.53, 1.0049, 1.46 and 1.45 g respectively).

In the 2nd year, the treatment FC+PM with PSB+Rhz combination registered significantly higher values than the treatment PSB+CU alone. Treatments FC+PM alone and with PSB+CU and PSB+Rhz alone were statistically at par with the most effective treatment.

Table 4.08.3(b) Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of fodder cowpea (g/plant) at 30 DAS

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	4.58	4.24	4.01	4.28	4.77	7.32	5.73	5.94
C_1	4.21	5.04	4.66	4.64	5.65	6.34	6.38	6.12
C_2	5.16	3.62	5.38	4.72	6.87	6.17	6.63	6.55
Mean	4.65	4.30	4.69		5.76	6.61	6.24	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		0.79	1.58			0.98	1.96	

At 30 DAS in the 1st year, the treatment combination FC+PM with PSB+CU recorded significantly higher value of 5.38 g than all other treatments [Table 4.08.3(b)].

In the 2nd year, the treatment PSB+Rhz alone recorded significantly higher value than control (7.32 and 4.77 g respectively). Treatment FC+PM (6.86 g) was statistically comparable with the most effective treatment.

Table 4.08.3(c) Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of fodder cowpea (g/plant) at 45 DAS

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	8.94	13.28	12.74	11.65	12.73	20.06	16.04	16.28
C_1	13.23	17.21	15.43	15.29	19.09	19.13	17.07	18.43
C_2	11.78	12.84	15.12	13.25	17.95	13.57	20.46	17.33
Mean	11.32	14.44	14.43		16.59	17.59	17.86	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		2.22	4.45			2.73	5.48	

At 45 DAS in the 1st year [Table 4.08.3(c)], treatment FC+VC with PSB+Rhz registered significantly higher value than treatment PSB+CU alone (17.21 and 12.74 g respectively). Treatments PSB+CU with FC+VC and with FC+PM were comparable with the most effective treatment (15.43 and 15.12 g respectively).

In the 2nd year treatment FC+PM with PSB+CU recorded significantly higher value than treatment FC+PM with PSB+Rhz (20.46 and 13.57 g respectively). Treatments PSB+Rhz alone, FC+VC alone and with PSB+Rhz were statistically at par with the most effective treatment.

Table 4.08.3(d) Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of fodder cowpea (g/plant) at 60 DAS

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	18.01	24.59	23.04	21.88	20.82	30.07	27.15	26.01
C_1	19.31	25.03	27.51	23.95	26.65	28.89	30.62	28.72
C_2	22.77	23.60	24.22	23.53	28.11	29.81	29.82	29.25
Mean	20.03	24.41	24.92		25.19	29.59	29.20	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.18	8.38			1.74	3.49	

At 60 DAS in the 1st year treatment combnation FC+VC with PSB+CU (27.51 g) was significantly higher than the control plots. [Table 4.08.3(d)].

In the 2nd year, the treatment FC+VC with PSB+CU combination registered significantly higher values than the treatment FC+VC alone (30.62 and 26.65 g respectively). Treatments PSB+Rhz alone, FC+PM with PSB+CU and with PSB+Rhz, FC+VC with PSB+Rhz, FC+PM alone and PSB+CU alone were statistically at par with the most effective treatment.

4.3.2 Nodulation pattern

4.3.2.1 Fertilizer levels

In both the years (Table 4.09) at successive stages there was no significant difference in the nodule count in the various treatments as a result of the different levels of fertilizers. However, the highest values were registered at almost all stages in the 0 level fertilizer combinations, except at 45 and 60 DAS in the 2nd year when the 33% RDF was responsible for maximizing the nodule count.

4.3.2.2 Manurial forms

Significant differences in nodule count values in the various treatments as a result of the forms of manures were not observed at any stage during both the years (Table 4.09). Nevertheless, the maximum figures in the successive stages were registered in either of the manurial forms, except at 45 DAS in the 1st year.

Table 4.09 **Effect of INM on nodulation of fodder cowpea (number/plant) during 1997-98 and 1998-99**

Factors	15 DAS		30 DAS		45 DAS		60 DAS	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Levels of Fertilizers (F):								
F_0	15.75	29.74	38.77	39.06	49.28	36.29	39.95	26.84
F_1	11.42	23.79	30.34	38.55	39.07	36.50	37.76	28.05
F_2	10.48	22.82	32.28	29.32	38.81	31.15	36.73	25.82
	NS	NS	NS	NS	NS	NS	NS	NS
Forms of manure (C):								
C_0	12.17	20.80	32.45	30.33	43.11	33.17	30.82	25.87
C_1	12.58	30.48	33.53	36.14	42.97	38.84	41.48	25.16
C_2	12.90	25.07	35.42	40.45	41.08	30.94	42.13	29.68
	NS	NS	NS	NS	NS	NS	NS	NS
Biofertilizers and/or organic spray (B):								
B_0	11.07	24.05	32.97	33.91	41.50	32.78	30.39	28.40
B_1	12.81	27.27	40.43	34.03	41.43	32.54	37.28	28.06
B_2	13.76	25.03	28.00	38.98	44.23	37.63	46.76	24.24
	NS	NS	NS	NS	NS	NS	*	NS
SEd ±	2.392	4.536	6.281	6.238	7.810	5.563	6.357	4.480
CD(0.05)	-	-	-	-	-	-	12.757	-
FxC FxB CxB:								
SEd ±	4.143	7.857	10.880	10.810	13.530	9.636	11.010	7.760
CD(0.05)	8.315	15.768	21.830	21.690	27.150	19.339	22.097	15.574

*Significant at P = 0.05 NS = non-significant

4.3.2.3 Biofertilizer and/or organic spray

Significant difference in the nodule count values in the various treatments as a result of the biofertilizer and/or organic spray was observed only at 60 DAS in the 1st year (Table 4.09). The maximum value at that stage was 46.76 followed by 37.28 registered respectively in treatments PSB+CU and PSB+Rhz. Further, it was noted that the higher values at successive stages were obtained in either of these treatments, except at 60 DAS in the 2nd year.

4.3.2.4 Interaction effect of fertilizer levels and manurial forms

Table 4.09.1(a) **Effect of interaction of fertilizer levels and manurial forms on nodule count of fodder cowpea (number/plant) at 15 DAS**

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	17.00	15.59	14.66	15.75	23.70	30.74	34.78	29.74
F_1	9.26	10.89	14.11	11.42	17.44	28.33	25.59	23.79
F_2	10.26	11.25	9.92	10.48	21.26	32.37	14.85	22.83
Mean	12.17	12.58	12.90		20.80	30.48	25.07	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.14	8.32			7.86	15.77	

The interaction of fertilizer levels and manurial forms did not significantly affect the nodule count at 15 DAS in the 1st year [Table 4.09.1(a)]. However, in the 2nd year the treatment FC+PM recorded significantly higher values than treatment 33% RDF

alone (34.78 and 17.44 respectvely). Treatments FC+VC alone and with 100% RDF were statistically at par with the most effective treatment.

Table 4.09.1(b) **Effect of interaction of fertilizer levels and manurial forms on nodule count of fodder cowpea (number/plant) at 30 DAS**

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	41.48	34.66	40.18	38.77	32.37	43.26	41.55	39.06
F_1	30.66	27.96	32.41	30.34	32.40	35.26	48.00	38.55
F_2	25.22	37.96	33.66	32.28	26.22	29.92	31.81	29.32
Mean	32.45	33.53	35.42		30.33	36.15	40.45	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		10.88	21.84			10.81	21.70	

At 30 DAS in the 1st year [Table 4.09.1(b)] no significant difference as a result of interaction between the fertilizer was observed with regard to the nodule count. However, the maximum value was observed in the control plot followed by FC+PM alone, 100% RDF with FC+VC, FC+VC alone, 100% RDF with FC+PM, 33% RDF with FC+PM and 33% RDF alone (41.48, 40.18, 37.96, 34.66, 33.66, 32.41 and 30.66 respectively).

In the 2nd year, the treatment combination 33% RDF with FC+PM registered the highest nodule count value which was significantly above treatment 100% RDF alone (48.00 and 26.22 respectively).

Table 4.09.1(c) **Effect of interaction of fertilizer levels and manurial forms on nodule count of fodder cowpea (number/plant) at 45 DAS**

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_1	Mean
F_0	49.48	50.26	48.11	49.28	37.59	41.03	30.26	36.29
F_1	39.22	33.92	44.07	39.07	38.85	39.25	31.41	36.50
F_2	40.63	44.74	31.07	38.81	23.07	36.22	31.14	30.14
Mean	43.11	42.97	41.08		33.17	38.83	30.94	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		13.53	27.15			9.64	19.34	

At 45 DAS in the 1st year [Table 4.09.1(c)] no significant difference was observed in the nodule count. However, the maximum value was obtained in the treatment FC+VC alone and the minimum in 100% RDF with FC+PM (50.26 and 31.07 respectively).

In the 2nd year also no significant difference was observed, but the maximum and minimum counts were registered in the treatments FC+VC alone and 100% RDF alone respectively.

Table 4.09.1(d) **Effect of interaction of fertilizer levels and manurial forms on nodule count of fodder cowpea (number/plant) at 60 DAS**

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	29.63	39.40	50.81	39.95	24.92	26.66	28.92	26.83
F_1	30.40	39.96	42.92	37.76	26.92	29.55	27.66	28.04
F_2	32.44	45.07	32.66	36.72	25.77	19.26	32.44	25.82
Mean	30.82	41.48	42.13		25.87	25.16	29.67	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		11.01	22.10			7.76	15.57	

At 60 DAS in the 1st year [Table 4.09.1(d)] though no significant difference was noticeable as a result of the interaction beteween the fertilizer levels and manurial forms, the highest value was recorded in the treatment FC+PM and the lowest was in control plots (50.81 and 29.63 respectively).

In the 2nd year the maximum reading was noted in the 100% RDF with FC+PM combination and the penultimate value was in the control plots (32.44 and 19.26).

4.3.2.5 Interaction due to levels of fertilizer and biofertilizer and/or organic spray

Table 4.09.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on nodule count of fodder cowpea (number/plant) at 15 DAS**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	13.41	15.70	18.15	15.75	23.85	36.22	29.15	29.74
F_1	9.44	11.55	13.26	11.42	25.29	19.81	26.26	23.79
F_2	10.37	11.18	9.89	10.48	23.00	25.77	19.70	22.82
Mean	11.07	12.81	13.77		24.05	27.27	25.04	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		4.14	8.32			7.86	15.77	

The interaction between the factors, *viz.*, fertilizer levels and biofertilizer and/or organic spray did not show [Table 4.09.2(a)] substantial affect on the nodule count at 15 DAS in the 1st year, except the PSB+CU treatment which was significantly superior to 33% RDF alone (18.15 and 9.44 respectively).

In the 2nd year a similar trend was noticed with the PSB+Rhz treatment registering a significantly higher nodule count over treatment combinations 100% RDF with PSB+CU and 33% RDF with PSB+Rhz (36.22, 19.70 and 19.81 respectively).

At 30 DAS in the 1st year no significant difference between treatments as a result of the interaction was observed [Table 4.09.2(b)]. However the maximum and

minimum values of 45.33 and 25.77 respectively were noted in treatments PSB+CU and 100% RDF with PSB+Rhz.

Table 4.09.2(b) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on nodule count of fodder cowpea (number/plant) at 30 DAS

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	41.44	29.55	45.33	38.77	31.74	38.18	47.26	39.06
F_1	27.26	28.66	35.11	30.34	38.55	33.74	43.37	38.55
F_2.	30.22	25.77	40.85	32.28	31.44	30.18	26.33	29.32
Mean	32.97	27.99	40.43		33.91	34.03	38.99	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		10.88	21.84			10.81	21.70	

In the 2nd year also somewhat similar trend was observed with the maximum and minimum values of 47.26 and 26.33 respectively registering in treatments PSB+CU alone and 100% RDF with PSB+CU.

Table 4.09.2(c) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on nodule count of fodder cowpea (number/plant) at 45 DAS

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	50.77	39.18	57.88	49.28	35.03	38.66	35.18	36.29
F_1	34.29	45.44	37.48	39.07	33.40	37.29	38.81	36.50
F_2	39.44	39.66	37.33	38.81	29.89	21.66	38.89	30.15
Mean	41.50	41.43	44.23		32.77	32.54	37.63	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		13.53	27.15			9.64	19.34	

At 45 DAS in the 1st year there was no significant difference in the nodule count. However, the highest and the lowest figures of 57.88 and 34.29 were respectively recorded in treatments PSB+CU alone and 33% alone [Table 4.09.2(c)].

In the 2nd year again there was no significant difference as a result of interaction between fertilizer and biofertilizer and/or organic spray. However, the maximum and minimum figures were registered in treatment combinations 100% RDF with PSB+CU and with PSB+Rhz (38.89 and 21.66 respectively).

Table 4.09.2(d) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on nodule count of fodder cowpea (number/plant) at 60 DAS

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	30.15	34.11	55.59	39.95	29.18	31.44	19.89	26.84
F_1	25.44	43.81	44.03	37.76	28.92	28.70	26.51	28.04
F_2	35.59	33.92	40.66	36.72	27.11	24.03	26.33	25.82
Mean	30.39	37.28	46.76		28.40	28.06	24.24	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		11:01	22.10			7.76	15.57	

At 60 DAS in the 1st year treatment PSB+CU alone recorded significantly higher value than 33% RDF alone (55.59 and 25.44 respectively). In the 2nd year also no significant differences were observed [Table 4.09.2(d)].

4.3.2.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

Table 4.09.3(a) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on nodule count of fodder cowpea (number/plant) at 15 DAS**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	10.40	13.44	12.66	12.17	19.00	24.11	19.29	20.80
C_1	9.81	12.70	15.22	12.58	28.81	30.55	32.07	30.48
C_2	13.00	12.29	13.40	12.90	24.33	27.14	23.74	25.07
Mean	11.07	12.81	13.76		24.05	27.27	25.03	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.14	8.32			7.86	15.77	

Significant dfferences due to interaction between the factors, *viz.*, manurial forms and biofertilizer and/or organic spray in the various treatments were absent at 15 DAS in both the years [Table 4.09.3(a)]. Nevertheless, maximum nodule count values in the 1st year were obtained in treatment FC+VC with PSB+CU combination and minimum in treatment FC+VC alone (15.22 and 9.81 respectively). In the 2nd year the corresponding figures of 32.07 and 19.00 were registered by treatments FC+VC with PSB+Rhz and in control plots respectively.

Table 4.09.3(b) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on nodule count of fodder cowpea (number/plant) at 30 DAS**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	27.00	32.55	37.81	32.45	31.55	24.89	34.55	30.33
C_1	29.18	30.00	41.41	33.53	28.74	38.51	41.18	36.14
C_2	42.74	21.44	42.07	35.42	41.44	38.70	41.22	40.45
Mean	32.97	28.00	40.43		33.91	34.03	38.98	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		10.88	21.84			10.81	21.70	

At 30 DAS in both the years no significant differences between treatments were noticed [Table 4.09.3(b)]. The maximum figures were registered in treatment FC+PM alone (42.74 and 41.44 respectively) and minimum values of 21.44 and 24.89 during the 1st and 2nd years were obtained respectively in treatments PSB+Rhz with FC+PM and PSB+Rhz alone.

Table 4.09.3(c) Effect of interaction of manurial forms and biofertilizer and/or organic spray on nodule count of fodder cowpea (number/plant) at 45 DAS

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	47.55	45.00	36.77	43.11	35.29	30.00	34.22	33.17
C_1	25.48	45.85	57.59	42.97	39.55	33.44	43.51	38.83
C_2	51.48	33.44	38.33	41.08	23.48	34.18	35.14	30.93
Mean	41.50	41.43	44.23		32.77	32.54	37.62	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		13.53	27.15			9.64	19.34	

The data on nodule count at 45 DAS in both the years did not show any marked difference between treatments [Table 4.09.3(c)]. The highest value in both the years were recorded in treatment FC+VC with PSB+CU combinations (57.59 and 43.51 respectively). The lowest figures of 25.48 and 23.48 in the corresponding periods were recorded respectively in treatments FC+VC alone and FC+PM alone.

Table 4.09.3(d) Effect of interaction of manurial forms and biofertilizer and/or organic spray on nodule count of fodder cowpea (number/plant) at 60 DAS

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	28.22	34.18	30.07	30.82	26.33	29.14	22.14	25.87
C_1	35.63	40.81	48.00	41.48	21.70	30.41	23.37	25.16
C_2	27.33	36.85	62.22	42.13	37.18	24.63	27.22	29.68
Mean	30.39	37.28	46.76		28.40	28.06	24.24	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		11.01	22.10			7.76	15.57	

At 60 DAS in the 1st year the treatment FC+PM with PSB+CU registered significantly higher nodule count values than in FC+PM alone (62.22 and 27.33 respectively). However, in the 2nd year no significant difference was observed and the maximum and minimum values of 37.18 and 21.70 were recorded respectively in treatments FC+PM alone and FC+VC alone [Table 4.09.3(d)].

4.3.3 Fodder yield (fresh weight and dry weight basis)

4.3.3.1 Fertilizer levels

Significant difference as a result of varying levels of fertilizer in the fodder yield (fresh weight basis) was absent in the 1st year but noticeable in the 2nd year (Table 4.10). The maximum values were registered in the 33% RDF combination (104.40 and 131.70 q ha^{-1} respectively). Treatment combination with 100% RDF was statistically comparable in the 2nd year (131.40 q ha^{-1}).

In both the years the fodder yield on dry weight basis was significantly higher in treatments with 100% RDF (44.97 and 50.56 q ha^{-1}) than with 33% RDF (41.84 and 38.29 q ha^{-1}), which in turn were superior to the 0 level RDF combinations (32.68 and 33.93 q ha^{-1}respectively).

The treatment 33% RDF registered significantly higher values of carbohydrate (dry weight basis) in the forage of cowpea over the control, which in turn recorded higher figures than treatment 100% RDF (51.72, 49.24 and 46.03% respectively). However, the treatment 100% RDF produced significantly higher protein content than treatment 33% RDF, which in turn was superior to control plots (5.92, 5.13 and 4.56% respectively).

Table 4.10 Effect of INM on herbage yield (fresh weight and dry weight basis), carbohydrate and protein content of fodder cowpea in the cropping system during 1997-98 and 1998-99

Factors	Yield (fresh weight basis) q ha^{-1}		Yield (dry weight basis) q ha^{-1}		Carbohydrate content of fodder (%)	Protein content of fodder (%)
	1997-98	1998-99	1997-98	1998-99	1998-99	
Fertilizer levels (F):						
F_0	92.73	102.60	32.68	33.93	49.24	4.56
F_1	104.40	131.70	41.84	38.29	51.72	5.13
F_2	97.87	131.40	44.97	40.56	46.03	5.92
	NS	*	*	*	*	*
Manurial forms (C):						
C_0	82.52	106.20	36.06	34.78	49.04	4.52
C_1	113.40	128.90	45.30	41.63	48.57	4.94
C_2	99.14	130.70	38.13	46.37	49.37	6.95
	*	*	*	*	*	*
Biofertilizer &/or organic spray (B):						
B_0	86.02	113.10	35.28	36.34	49.82	4.58
B_1	109.10	131.20	42.12	46.73	47.76	6.30
B_2	99.89	120.90	42.10	36.34	49.40	4.72
	*	*	*	*	*	*
SEd ±	8.3339	6.2505	1.2965	0.5103	0.1024	0.0371
CD(0.05)	16.734	12.543	2.6015	1.0241	0.2055	0.0744
FxC FxB CxB :						
SEd ±	14.440	10.830	2.246	0.8840	0.1770	0.0643
CD(0.05)	28.980	21.730	4.507	1.7740	0.3550	0.1290

*Significant at P = 0.05 NS = non-significant

4.3.3.2 Manurial forms

The treatment FC+VC recorded significantly higher yield in the 1st year than other treatment combinations. The values obtained on fresh weight and dry weight basis were 113.40 and 45.30 q ha^{-1} respectively (Table 4.10). In the 2nd year significantly higher yields were registered by treatment FC+PM, and treatment FC+VC was statistically comparable with the best treatment. The fresh weight basis yields produced by the corresponding treatments were 130.70 and 128.90 q ha^{-1}. On dry

weight basis the treatment FC+VC was statistically not at par with the best treatment and the values were 46.37 and 41.63 q ha^{-1} respectively.

The manurial form FC+PM registered markedly higher values of carbohydrate and protein in fodder cowpea in the cropping system (49.37 and 6.15% respectively). The treatment FC+VC was superior to the control plot with regard to protein but was inferior with respect to carbohydrate content.

4.3.3.3 Biofertilizer and/or organic spray

Significant differences in the herbage yield as a result of the biofertilizer and/or organic spray were observed during both the years (Table 4.10). In the 1st and 2nd years the fodder yield on fresh weight basis was respectively 109.10 and 131.20 q ha^{-1} in treatment PSB+Rhz and was significantly above the 0 level combinations. The figures obtained in PSB+CU combinations were comparable with the former treatment. However, on dry weight basis the figures in 1st and 2nd years were 42.12 and 46.73 q ha^{-1} in the treatment PSB+Rhz, and only in the 1st year the treatment PSB+CU (42.10 q ha^{-1}) was statistically comparable with the former combination.

PSB+CU was respectively superior to treatment PSB+Rhz and control with regard to carbohydrate and protein content. However, the highest values of these parameters were registered in the control plot and PSB+Rhz respectively (49.82 and 6.30 respectively).

4.3.3.4 Interaction effect of fertilizer levels and manurial forms

Table 4.10.1(a) Effect of interaction of fertilizer levels and manurial forms on the cowpea fodder yield (fresh weight basis) (q ha^{-1}) at harvest

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	55.15	109.00	114.10	92.75	61.36	115.00	131.50	102.62
F_1	97.50	116.10	99.72	104.44	126.40	136.90	132.00	131.76
F_2	94.91	115.10	83.61	97.87	130.90	134.70	128.50	131.36
Mean	82.52	113.40	99.14		106.22	128.86	130.66	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		14.44	28.98			10.83	21.73	

The fresh weight of fodder cowpea at harvest was markedly influenced by the interaction of fertilizer levels and manurial forms [Table 4.10.1(a)]. The treatment 33% RDF with FC+VC registered significantly higher yield than treatment combination 100% RDF with FC+PM (116.10 and 83.61 q ha^{-1} respectively). Treatments 100% RDF

alone and with FC+VC, FC+PM alone, FC+VC alone, 33% RDF alone and with FC+VC were statistically comparable with the most effective treatment combination.

In the 2nd year the treatment 33% RDF with FC+VC produced significantly higher yield (fresh weight basis) over control, and all other treatments were statistically at par with the most effective treatment.

Table 4.10.1(b) Effect of interaction of fertilizer levels and manurial forms on the cowpea fodder yield (dry weight basis) (q ha^{-1}) at harvest

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	17.77	36.04	44.24	32.68	19.60	38.41	43.77	33.93
F_1	46.45	42.13	36.95	41.84	36.31	32.42	46.16	38.30
F_2	43.95	57.74	33.21	44.96	48.43	54.06	49.20	50.56
Mean	36.05	45.30	38.13		34.78	41.63	46.38	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		2.24	4.50			0.88	1.77	

The data on herbage yield on dry weight basis in the 1st year shows that the treatment 100% RDF with FC+VC was highly significant over treatment 33% RDF alone (57.74 and 46.45 q ha^{-1}). However, the treatments FC+PM alone, 100% RDF and 33% RDF with FC+VC were statistically on par with the treatment 33% RDF alone [Table 4.10.1(b)].

In the 2nd year the treatment 100% RDF with FC+VC registered significantly higher yield (dry weight basis) than 100% RDF with FC+PM. Treatment 100% RDF alone was comparable with latter treatment and together were significantly above treatment 33% RDF with FC+PM. However, the treatment FC+PM alone was on par with the treatment 33% RDF with FC+PM.

Table 4.10.1(c) Effect of interaction of fertilizer levels and manurial forms on carbohydrate and protein content of fodder cowpea during 1998-99

Factors	Carbohydrate (%)				Protein (%)			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	48.06	48.02	51.65	49.24	3.86	4.74	5.09	4.56
F_1	55.61	50.00	49.54	51.72	5.32	5.18	4.88	5.13
F_2	43.46	47.70	46.91	46.02	4.40	4.90	8.47	5.92
Mean	49.04	48.57	49.37		4.53	4.94	6.15	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		0.177	0.356			0.064	0.129	

Interaction between fertilizer levels and manurial forms influenced the carbohydrate level in fodder cowpea [Table 4.10.1(c)]. Maximum values were observed in 33% RDF alone and FC+PM alone. The treatment combinations of 33% RDF with

FC+VC and with FC+PM were significantly superior to all treatment combinations except 33% RDF alone and FC+PM alone. However, treatment combination 100% RDF with FC+PM proved to be superior with regard to protein content of the herbage and was significantly above treatment 33% RDF alone which in turn performed better than the treatment combination 33% RDF with FC+VC (8.47, 5.32 and 5.18% respectively). Further the treatment 33% RDF with FC+VC was superior to other treatments except FC+PM alone.

4.3.3.5 Interaction effect due to fertilizer and biofertilizer and/or organic spray

Table 4.10.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on the cowpea fodder yield (fresh weight basis) (q ha^{-1}) at harvest**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	74.09	111.80	92.35	92.74	85.67	116.00	106.20	102.62
F_1	91.02	117.90	104.40	104.44	125.70	140.10	129.40	131.73
F_2	92.96	97.78	102.90	97.88	129.80	137.40	126.90	131.36
Mean	86.02	109.16	99.88		113.72	131.16	120.83	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		14.44	28.98			10.83	21.73	

The fresh weight basis fodder yield of cowpea in the system in the 1st year recorded highly significant values in treatment 33% RDF with PSB+Rhz over treatment 100% RDF with PSB+CU. Treatments PSB+Rhz and 33%RDF with PSB+CU were statistically comparable with the most effective treatment combination [Table 4.10.2(a)].

In the 2nd year the treatment 33% RDF with PSB+Rhz registered significantly higher values than treatment PSB+Rhz alone (140.10 and 116.00 q ha^{-1}). Treatments 100% RDF alone, with PSB+Rhz and with PSB+CU, 33% RDF alone and with PSB+CU were statistically on par with the most effective treatment.

Table 4.10.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on the cowpea fodder yield (dry weight basis) (q ha^{-1}) at harvest**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	25.65	37.05	35.35	32.68	27.36	40.83	33.60	33.93
F_1	39.95	42.12	43.47	41.85	37.58	41.95	35.35	38.29
F_2	40.24	47.18	47.48	44.97	44.09	57.41	50.19	50.56
Mean	35.28	42.12	42.10		36.34	46.73	39.71	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		2.25	4.51			0.88	1.77	

The yield data on dry weight basis was significantly higher in treatment 100% RDF with PSB+CU than in treatment 33% RDF with PSB+Rhz in the 1st year (47.48 and 42.12 q ha^{-1}). Treatments 100% RDF with PSB+Rhz and 33% RDF with PSB+CU were statistically comparable with the most effective treatment. Further, it was noted that treatments 100% RDF alone and 33% alone were comparable with 33% RDF with PSB+Rhz [Table 4.10.2(b)].

In the 1st year the data on the dry weight basis fodder yield showed highly significant figures in the treatment combination 100% RDF with PSB+Rhz than treatment 100% RDF with PSB+CU, which in turn was markedly higher than treatment 100% RDF alone (57.41, 50.19, 44.09 q ha^{-1} respectively).

Table 4.10.2(c) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on carbohydrate and protein content of fodder cowpea during 1998-99

Factors	Carbohydrate (%)				Protein (%)			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	48.44	43.21	56.08	49.24	3.65	6.02	4.02	4.56
F_1	52.95	54.09	48.10	51.71	4.50	6.80	4.08	5.13
F_2	48.08	45.98	44.02	46.03	5.60	6.10	6.07	5.92
Mean	49.82	47.76	49.40		4.58	6.31	4.72	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.177	0.356			0.064	0.129	

The interaction between fertilizer levels and biofertlizer and/or organic spray showed influence on the carbohydrate levels of seeds [Table 4.10.2(c)]. Though the treatment PSB+CU registered the maximum figure and significantly higher than 33% RDF with PSB+Rhz, the latter combination proved to be superior to other treatments. Interactive effect of fertilizer levels and biofertilzer and/or organic spray on protein content was clearly evident with treatment 33% RDF with PSB+Rhz registering highest value followed by treatment 100% RDF with PSB+Rhz, which in turn was superior to 100% RDF alone. Further, the treatments 100% RDF with PSB+CU and PSB+Rhz alone were comparable with the second best treatment combination, *viz.*, 100% RDF with PSB+Rhz.

4.3.3.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

In the 1st year the yield (fresh weight basis) in treatment FC+VC with PSB+Rhz was significantly higher than in treatment FC+VC alone (128.00 and 97.41 q ha^{-1}). The

treatments FC+VC with PSB+CU, FC+PM with PSB+Rhz and with PSB+CU were statistically comparable with the most effective treatment [Table 4.10.3(a)].

Table 4.10.3(a) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on the cowpea fodder yield (fresh weight basis) (q ha^{-1}) at harvest**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	67.43	94.35	85.78	82.52	85.84	127.10	105.70	106.21
C_1	97.41	128.00	114.80	113.40	122.50	130.80	133.20	128.83
C_2	93.24	105.10	99.07	99.13	132.80	135.60	123.70	130.70
Mean	86.02	109.15	99.88		113.71	131.16	120.86	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		14.44	28.98			10.83	21.73	

In the 2nd year the treatment FC+VC with PSB+Rhz registered significantly higher value than the control plot (135.60 and 85.84q ha^{-1}). All other treatments were statistically at par with the most effective treatment.

Table 4.10.3(b) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on the cowpea fodder yield (dry weight basis) (q ha^{-1}) at harvest**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	39.18	32.43	36.56	36.06	30.04	39.21	35.10	34.78
C_1	32.71	50.89	52.31	45.30	34.76	49.95	40.18	41.63
C_2	33.95	43.04	37.41	38.13	44.23	51.04	43.86	46.38
Mean	35.28	42.12	42.09		36.34	46.73	39.71	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		2.25	4.51			0.88	1.77	

The herbage yield on dry weight basis was significantly higher in treatment FC+VC with PSB+CU over FC+PM with PSB+Rhz (52.31 and 43.04 q ha^{-1} respecively). Treatment FC+VC with PSB+Rhz was statistically comparable with the best combination. The minimum value of 32.43 q ha^{-1} was recorded in treatment PSB+Rhz alone [Table 4.10.3(b)].

In the 2nd year the data pertaining to the yield (dry weight basis) showed that the treatment FC+PM with PSB+Rhz registered significantly higher value than treatment FC+PM alone (51.04 and 44.23 q ha^{-1} respectively). The treatment FC+VC with PSB+Rhz (49.95 q ha^{-1}) was statistically on par with the most effective treatment. The minimum value (30.04 q ha^{-1}) was obtained in the 0 level combination of both the factors.

The interaction between the manurial forms and biofertilizer and/or organic spray [Table 4.10.3(c)] on the carbohydrate content was revealed in treatment

combination FC+PM with PSB+CU (53.46%), which was superior to all other treatments except treatment FC+VC alone (54.52%). The maximum protein content in the herbage as a result of this interaction was expressed by treatment combination FC+PM with PSB+Azsp followed by treatments FC+VC with PSB+Azsp and with PSB+CU combinations (8.53, 5.62 and 5.22% respectively). Each of these treatments were statistically superior to the successive one, which in turn were superior to all other treatments.

Table 4.10.3(c) Effect of interaction of manurial forms and biofertilizer and/or organic spray on carbohydrate and protein content of fodder cowpea during 1998-99

Factors	Carbohydrate (%)				Protein (%)			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	47.36	49.46	50.31	49.04	4.76	4.77	4.06	4.53
C_1	54.52	46.77	44.42	48.57	3.97	5.62	5.22	4.94
C_2	47.58	47.05	53.46	49.36	5.03	8.53	4.90	6.15
Mean	49.82	47.76	49.40		4.58	6.31	4.73	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.177	0.356			0.064	0.129	

4.3.4 Post-cropping soil status

4.3.4.1 Fertilizer levels

The post-cropping status of some of the parameters of soil in the system was significantly influenced as a result of the varying levels of fertilizer (Table 4.11). The soil pH was least (7.84) and organic carbon content was highest (0.320%) in the treatment with 33% RDF combination in the 1st year. The EC_{25} was least (0.090 dS m^{-1}) in the treatment with 100% RDF combination in the 2nd year. Statistical comparability with treatment 100% RDF in the 1st year and with treatment 33% RDF in the 2nd year was noticed in all the three cases.

4.3.4.2 Manurial forms

The available potassium level (Table 4.11) in the 1st year was significantly higher in treatment FC+PM than in the 0 level treatment (447.10 and 382.50 kg ha^{-1} respectively). Statistically comparable figure was obtained in treatment FC+VC (411.40 kg ha^{-1}).

In the 2nd year the soil pH (7.70) and EC_{25} (0.091 dS m^{-1}) were significantly lower in the treatment FC+PM than in control. Statistical comparability was noticed in the treatment FC+VC (pH 7.75 and 0.097 dS m^{-1} respectively).

Table 4.11 **Effect of fodder cowpea cropping under INM system on the Physico-chemical properties of the soil**

Factors	pH		EC_{25} (dS m^{-1})		Organic carbon(%)		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Levels of Fertilizers (F):										
F_0	7.90	7.77	0.190	0.135	0.238	0.535	28.07	24.74	392.20	400.10
F_1	7.84	7.74	0.188	0.094	0.320	0.585	25.67	32.56	418.10	478.00
F_2	7.86	7.71	0.187	0.090	0.297	0.517	21.81	32.44	430.80	366.30
	*	NS	NS	*	*	NS	NS	NS	NS	NS
Forms of manure (C):										
C_0	7.88	7.77	0.194	0.130	0.260	0.540	24.07	17.74	382.50	406.80
C_1	7.85	7.75	0.184	0.097	0.285	0.562	23.56	35.59	411.40	440.60
C_2	7.87	7.70	0.187	0.091	0.311	0.535	27.93	36.41	447.10	396.90
	NS	*	NS	*	NS	NS	NS	*	*	NS
Biofertilizers and/or organic spray (B):										
B_0	7.87	7.74	0.195	0.122	0.283	0.495	21.93	30.74	410.70	381.10
B_1	7.87	7.72	0.180	0.092	0.286	0.569	25.48	31.56	400.90	406.60
B_2	7.87	7.77	0.191	0.105	0.286	0.573	28.15	27.44	429.60	456.70
	NS	NS	*	*	NS	NS	NS	NS	NS	NS
SEd ±	0.0152	0.0253	0.0051	0.0118	0.0214	0.0483	0.398	5.247	25.251	59.845
CD(0.05)	0.0306	0.0508	0.0103	0.0238	0.0430	-	-	10.53	50.671	-
FxC FxB CxB:										
SEd ±	0.0264	0.0439	0.0089	0.0205	0.0371	0.0838	6.903	9.089	43.74	103.70
CD(0.05)	0.0530	0.0881	0.0179	0.0413	0.0745	0.1682	13.854	18.241	87.786	208.12

*Significant at $P = 0.05$ NS = non-significant

The available phosphorus level was markedly higher in the treatment FC+PM than the 0 level combinations (36.41 and 17.74 kg ha^{-1} respectively). The figure recorded in treatment FC+VC (35.59 kg ha^{-1}) was at par with that in treatment FC+PM.

4.3.4.3 Biofertilizer and/or organic spray

Signficantly lower values of EC_{25} were obtained (Table 4.11) in treatment PSB+Rhz than in the 0 level combinations in the 1st and 2nd year (0.180 and 0.195 in the 1st year and 0.092 and 0.122 in the 2nd year dS m^{-1} respectively). Statistical comparability was noted in treatment PSB+CU (0.105 dS m^{-1}) in the 2nd year.

4.3.4.4Interaction effect due to fertilizer level and manurial forms

Table 4.11.1(a) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (fodder cowpea) status of soil EC_{25} (dS m^{-1})**

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.199	0.182	0.191	0.191	0.192	0.127	0.087	0.135
F_1	0.194	0.187	0.184	0.189	0.097	0.078	0.109	0.094
F_2	0.191	0.184	0.187	0.187	0.103	0.089	0.080	0.091
Mean	0.195	0.184	0.187		0.131	0.098	0.092	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.009	0.018			0.021	0.041	

Significant difference between the EC_{25} values of the various treatments due to the interaction of fertilizer levels and manurial forms was absent in the 1st year. However, the lowest value was recorded in treatments FC+VC alone followed by 33% RDF with FC+PM, 100% RDF with FC+VC (0.182, 0.184 and 0.184 dS m^{-1} respectively). The maximum value of 0.199 dS m^{-1} was obtained in the control plot [Table 4.11.1(a)].

However, in the 2nd year significantly lower value was registered in treatment 33% RDF with FC+VC than in treatment FC+VC alone (0.078 and 0.127 dS m^{-1} respectively). Treatment 100% RDF with FC+PM (0.080 dS m^{-1}) was on par with the most effective treatment. All other treatments showed comparability.

Table 4.11.1(b) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (fodder cowpea) status of soil organic carbon (%)**

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.186	0.250	0.280	0.239	0.502	0.558	0.546	0.535
F_1	0.318	0.313	0.330	0.320	0.616	0.592	0.548	0.585
F_2	0.277	0.293	0.323	0.298	0.504	0.537	0.512	0.518
Mean	0.260	0.286	0.311		0.541	0.562	0.535	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.037	0.075			0.084	0.168	

In the 1st year the treament 33% RDF with FC+PM registered significantly higher organic carbon than treatment FC+VC alone (0.33 and 0.25% respectively). Statistical comparability with the most effective treatment was noticed in all other treatments [Table 4.11.1(b)].

In the 2nd year no significant difference was observed between the various treatment combinations. However, the maximum value was obtained in treatment 33% RDF alone followed by treatment 33% RDF with FC+VC combination (0.616 and 0.592% respectively). The minimum figure was obtained in the control plots (0.502%).

Table 4.11.1(c) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (fodder cowpea) status of soil available P_2O_5 (kg ha^{-1})**

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	19.56	30.11	34.56	28.08	7.89	25.33	41.00	24.74
F_1	25.56	24.78	26.67	25.67	17.22	43.00	37.44	32.55
F_2	27.11	15.78	22.56	21.82	28.11	38.44	30.78	32.44
Mean	24.08	23.56	27.93		17.74	35.59	36.41	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		6.90	13.85			9.09	18.24	

The post-cropping available phosphorus status of the soil was significantly higher in treatment FC+PM alone than in control (34.56 and 19.56 kg ha^{-1} respectively). Treatment FC+VC alone (30.11 kg ha^{-1}) was statistically comparable with the most effective treatment [Table 4.11.1(c)].

In the 2nd year the treatment 33% RDF with FC+VC recorded significantly higher value than in FC+VC alone (43.00 and 17.22 kg ha^{-1}). Treatments FC+PM alone and with 33% RDF and 100% RDF with FC+VC were statistically at par with the most effective treatment.

Table 4.11.1(d) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (fodder cowpea) status of soil available K_2O (kg ha^{-1})**

Factors	1997-98				1998-1999			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	338.90	387.60	450.10	392.20	418.30	451.70	330.20	400.07
F_1	402.30	407.80	482.20	430.77	391.80	481.00	561.10	477.97
F_2	406.30	439.00	409.00	418.10	410.20	389.20	299.40	366.27
Mean	382.50	411.47	447.10		406.77	440.63	396.90	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		43.74	87.79			103.70	208.13	

In the 1st year the available potassium status was significantly influenced by the interaction of fertilizer levels and manurial forms. The treatment 33% RDF with FC+PM registered the highest figure and was superior to treatment FC+VC alone (482.20 and 387.60 kg ha^{-1} respectively). However, the treatment FC+PM alone (450.10 kg ha^{-1}) was statistically on par with the most effective treatment [Table 4.11.1(d)].

In the 2nd year the treatment 33% RDF with FC+PM registered significantly higher value than treatment FC+PM alone (561.10 and 330.20 kg ha^{-1}). The minimum value was recorded by treatment 100% RDF with FC+PM (299.40 kg ha^{-1}).

4.3.4.4 Interaction effect due to fertilizer levels and biofertilizer and/or organic spray

In the 1st year the EC_{25} value was significantly lower in treatment 33% RDF with PSB+Rhz than in treatment 33% RDF with PSB+CU (0.177 and 0.197 dS m^{-1} respectively). Treatments PSB+Rhz alone and 100% RDF with PSB+Rhz (0.182 dS m^{-1} in both) were statistically on par with the most effective treatment [Table 4.11.2(a)].

Table 4.11.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (fodder cowpea) status of soil EC_{25} (dS m^{-1})**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.204	0.182	0.186	0.191	0.189	0.091	0.126	0.135
F_1	0.192	0.177	0.197	0.189	0.087	0.082	0.114	0.094
F_2	0.189	0.182	0.191	0.187	0.092	0.104	0.076	0.091
Mean	0.195	0.180	0.191		0.123	0.093	0.105	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.009	0.018			0.021	0.041	

In the 2nd year treatment 100% RDF with PSB+CU registered significantly lower value than PSB+CU alone (0.076 and 0.126 dS m^{-1} respectively). Treatment 33% RDF with PSB+Rhz (0.082 dS m^{-1}) was statistically comparable with the most effective treatment. Further, it was noted that all treatments registered significantly lower values than the control (0.189 dS m^{-1}).

Table 4.11.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (fodder cowpea) status of soil organic carbon (%)**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.210	0.257	0.249	0.239	0.430	0.570	0.606	0.535
F_1	0.290	0.340	0.331	0.320	0.572	0.639	0.544	0.585
F_2	0.350	0.263	0.280	0.298	0.486	0.499	0.569	0.518
Mean	0.283	0.287	0.287		0.496	0.569	0.573	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.037	0.075			0.084	0.168	

In the 1st year the treatment 100% RDF alone showed significantly higher value of organic carbon than treatment 100% RDF with PSB+Rhz (0.350 and 0.263% respectively). Treatment 33% RDF with PSB+Rhz (0.34 0%) was statistically at par with the most effective treatment. Further, it was noted that all treatment combinations registered significantly higher value than control (0.210%) [Table 4.11.2(b)].

In the 2nd year treatment combination 33% RDF with PSB+Rhz recorded significantly higher value than control (0.639 and 0.430% respectively). Treatment PSB+CU alone (0.606%) was comparable with the most effective treatment.

In the 1st year the available phosphorus value was significantly higher in treatment PSB+CU than in treatment 100% RDF (38.22 and 25.11 kg ha-[1] respectively). Treatment PSB+Rhz alone (33.22 kg ha^{-1}) was statistically at par with the most effective treatment [Table 4.11.2(c)].

Table 4.11.2(c) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (fodder cowpea) status of soil available P_2O_5 (kg ha^{-1})

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	12.78	33.22	38.22	28.07	16.00	34.11	24.11	24.74
F_1	27.89	24.11	25.00	25.67	39.00	30.89	27.78	32.56
F_2	25.11	19.11	21.22	21.81	37.22	29.67	30.44	32.44
Mean	21.93	25.48	28.15		30.74	31.56	27.44	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		6.90	13.85			9.09	18.24	

In the 2nd year the treatment 33% RDF alone recorded significantly higher values than control plot (39.00 and 16.00 kg ha^{-1} respectively). Treatment 100% RDF alone (37.22 kg ha^{-1}) was statistically on par with the most effective treatment.

Table 4.11.2(d) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (fodder cowpea) status of soil available K_2O (kg ha^{-1})

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	389.10	367.10	420.30	392.17	389.70	358.10	452.40	400.07
F_1	437.60	402.00	452.80	430.80	382.00	491.90	560.00	477.97
F_2	405.30	433.40	415.60	418.10	371.60	369.70	357.70	366.33
Mean	410.67	400.83	429.57		381.10	406.57	456.70	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		43.74	87.79			103.70	208.13	

In both the years there was no significant difference between the available potassium values due to the interaction [Table 4.11.2(d)]. However, in the 1st year the maximum value was registered in treatment combination 33% RDF with PSB+CU followed by treatment 33%RDF alone (452.80 and 437.60 kg ha^{-1}). The minimum value was recorded in treatment PSB+Rhz alone (367.10 kg ha^{-1}).

In the 2nd year the maximum value was registered in treatment 33% RDF with PSB+CU followed by treatment 33% RDF with PSB+Rhz (560.00 and 491.90 kg ha^{-1}). The minimum value was recorded in treatment 100% RDF with PSB+CU (357.70 kg ha^{-1}).

4.3.4.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

In the 1st year the EC_{25} of the post-cropping soil sample test revealed that the treatment PSB+Rhz alone registered significantly lower value than treatment FC+PM alone (0.176 and 0.197 dS m^{-1} respectively). Treatments FC+VC alone and FC+PM

with PSB+Rhz (0.179 dS m^{-1} in both) were statistically comparable with the most effective treatment [Table 4.11.3(a)].

Table 4.11.3(a) **Effect of interaction of manurial levels and biofertilizer and/or organic spray on post-cropping (fodder cowpea) status of soil EC_{25} (dS m^{-1})**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.210	0.176	0.199	0.195	0.198	0.102	0.092	0.131
C_1	0.179	0.187	0.188	0.184	0.082	0.094	0.117	0.098
C_2	0.197	0.179	0.187	0.187	0.088	0.081	0.107	0.092
Mean	0.195	0.180	0.191		0.123	0.093	0.105	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.009	0.018			0.021	0.041	

In the 2nd year treatment FC+PM with PSB+Rhz recorded significantly lower figure than the control plot (0.081 and 0.198 dS m^{-1} respectively). All other treatment combinations were statistically on par with the most effective treatment.

Table 4.11.3(b) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (fodder cowpea) status of soil organic carbon (%)**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.250	0.293	0.237	0.260	0.477	0.568	0.578	0.541
C_1	0.310	0.250	0.297	0.286	0.520	0.594	0.572	0.562
C_2	0.290	0.317	0.327	0.311	0.491	0.546	0.569	0.535
Mean	0.283	0.287	0.287		0.496	0.569	0.573	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.037	0.075			0.084	0.168	

In the 1st year the treatment FC+PM with PSB+CU registered significantly higher value of percentage organic carbon than in treatment FC+VC with PSB+Rhz (0.327 and 0.250 respectively). The treatment FC+PM with PSB+Rhz (0.317%) was statistically comparable with the most effective treatment [Table 4.11.3(b)].

In the 2nd year no significant difference between treatments as a result of interaction of manurial forms and biofertilizer and/or organic spray was observable. However, the maximum and minimum values of 0.594 and 0.477% were recorded respectively in treatment FC+VC with PSB+Rhz and control.

In the 1st year the available phosphorus was significantly higher in treatment FC+PM with PSB+CU than in treatment FC+VC alone (33.89 and 17.11 kg ha^{-1}) [Table 4.11.3(c)].

Table 4.11.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (fodder cowpea) status of soil available P_2O_5 (kg ha^{-1})**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	24.78	24.78	22.67	24.08	23.56	14.22	15.44	17.74
C_1	17.11	25.67	27.89	23.56	36.33	35.00	35.44	35.59
C_2	23.89	26.00	33.89	27.93	32.33	45.44	31.44	36.40
Mean	21.93	25.48	28.15		30.74	31.55	27.44	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		6.90	13.85			9.09	18.24	

In the 2nd year the treatment FC+PM with PSB+Rhz registered the highest figure of available phosphorus which was significantly higher than the control plot (45.44 and 23.56 kg ha^{-1} respectively). Treatments FC+VC alone, with PSB+CU and with PSB+Rhz (36.33, 35.44 and 35.00 kg ha^{-1} respectively) were statistically comparable with the most effective treatment combination.

Table 4.11.3(d) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (fodder cowpea) status of soil available K_2O (kg ha^{-1})**

Factors	1997-98				1998-1999			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	324.10	412.70	410.80	382.53	339.60	386.40	494.30	406.77
C_1	438.20	388.10	408.00	411.43	475.40	484.30	362.10	440.60
C_2	469.70	401.80	469.90	447.13	328.20	348.90	513.70	396.93
Mean	410.67	400.87	429.57		381.07	406.53	456.70	
		SEd $\pm$	CD(0.05)			SEd $\pm$	CD(0.05)	
		43.74	87.79			103.70	208.13	

In the 1st year the data pertaining to the available potassium of soil revealed that significantly higher value was recorded in treatment FC+PM with PSB+CU combination than in control plot (469.90 and 324.10 kg ha^{-1} respectively). The treatments FC+PM alone, FC+VC alone and with PSB+Rhz 469.70, 438.20 and 412.70 kg ha^{-1} respectively) were statistically at par with the most effective treatment [Table 4.11.3(d)].

However, in the 2nd year no significant difference due to the interaction was observed. The maximum and minimum figures recorded were 513.70 and 328.20 kg ha^{1} respectively in treatment FC+PM with PSB+CU and FC+PM alone.

4.4 Experiment 2: (Blackgram – Wheat – Greengram system)
Crop component 1: Blackgram

4.4.1 Dry matter accumulation

4.4.1.1 Fertilizer levels

The dry matter accumulation of blackgram crop in the system was significantly influenced by the different levels of fertilizer at 15, 30 & 90 DAS in the 1st year and at all stages during the 2nd year (Table 4.12). In the 1st year significantly higher dry weight values in treatment 100% RDF over 0 level RDF were observed at 90 DAS and statistically on par figures were obtained in treatment 33% RDF (52.87 and 48.98 g respectively). However, throughout the crop period maximum values were recorded in either of the treatments, *viz.*, 100% or 33% RDF.

In the 2nd year at 15, 30 and 45 DAS the treatment 100% RDF registered significantly higher values than the 0 level RDF. Statistically comparable figures were obtained in treatment 33% RDF during these stages. Significantly higher values were recorded in treatment 33% RDF at 60, 75 and 90 DAS, and statistical comparability in treatment 100% RDF was noticeable at these stages.

4.4.1.2 Manurial forms

Significant influence on dry matter accumulation as a result of manurial forms was observable only at certain stages (Table 4.12). At 30 & 75 DAS in the 1st year the treatment FC+PM recorded significantly higher values than in other combinations. In the 2nd year at 15 DAS significantly higher figures were obtained in treatment FC+VC than the 0 level plot. Statistical comparability in treatment FC+PM was observed in the 2nd year. The maximum figures in all other stages in both the years were registered either in treatment FC+PM or FC+VC combination.

4.4.1.3 Biofertilizer and/or organic spray

The dry matter accumulation in blackgram crop in the system registered significantly higher figures in treatment PSB+CU (52.63 g) at 90 DAS in the 1st year and in treatment PSB+Rhz (0.346 g) at 15 DAS in the 2nd year (Table 4.12). The maximum values in all other stages in both the years were recorded either in treatment PSB+Rhz or PSB+CU.

Table 4.12 Effect of INM on dry weight of blackgram (g/plant) during 1997-98 and 1998-99

Factors	15 DAS		30 DAS		45 DAS		60 DAS		75 DAS		90 DAS	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Fertilizer levels (F):												
F_0	0.115	0.242	1.068	0.601	5.373	2.147	14.00	6.81	27.75	13.93	43.57	21.61
F_1	0.118	0.347	1.129	0.865	5.954	3.493	16.79	13.34	28.16	29.15	48.98	34.21
F_2	0.131	0.373	1.223	0.906	6.019	3.754	15.78	12.80	28.07	27.74	52.87	33.56
	*	*	*	*	NS	*	NS	*	NS	*	*	*
Forms of manure (C):												
C_0	0.116	0.296	1.052	0.743	5.435	3.146	15.06	10.24	26.07	22.80	45.74	27.30
C_1	0.120	0.340	1.231	0.785	6.006	2.978	16.52	11.26	26.41	21.82	49.13	30.74
C_2	0.129	0.325	1.136	0.843	5.905	3.270	14.99	11.44	31.49	26.20	50.54	31.33
	NS	*	*	NS	NS	NS	NS	NS	*	NS	NS	NS
Biofertilizer &/or Organic spray (B):												
B_0	0.119	0.309	1.083	0.755	5.656	2.867	14.05	9.85	24.80	21.65	45.90	29.49
B_1	0.125	0.346	1.097	0.805	6.128	3.319	16.97	11.44	28.62	24.06	46.89	31.44
B_2	0.119	0.307	1.239	0.811	5.561	3.208	15.57	11.66	30.55	25.12	52.63	28.45
	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	*	NS
SEd ±	0.007	0.016	0.079	0.051	0.442	0.251	2.70	0.944	2.330	2.097	2.500	2.621
CD(0.05)	0.014	0.032	0.158	0.104	-	0.505	-	1.894	4.680	4.209	5.020	5.251
FxC FxB CxB:												
SEd ±	0.013	0.028	0.138	0.089	0.765	0.436	2.330	1.636	4.040	3.634	4.340	4.540
CD(0.05)	0.026	0.056	0.276	0.180	1.537	0.875	4.680	3.283	8.110	7.293	8.710	9.111

*Significant at P = 0.05 NS = non-significant

4.4.1.4 Interaction due to fertilizer and manurial forms

Table 4.12.1(a) Effect of interaction of fertilizer levels and manurial forms on dry weight of blackgram (g/plant) at 15 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.097	0.122	0.128	0.116	0.187	0.260	0.280	0.242
F_1	0.110	0.117	0.128	0.118	0.333	0.348	0.361	0.347
F_2	0.141	0.121	0.132	0.131	0.370	0.413	0.336	0.373
Mean	0.116	0.120	0.129		0.297	0.340	0.326	
		SEd ± 0.013	CD(0.05) 0.026			SEd ± 0.028	CD(0.05) 0.057	

In the 1st year at 15 DAS the dry weight value was significantly higher in treatment 100% RDF alone than in treatment 33% RDF alone (0.141 and 0.097 g respectively). Treatments FC+PM alone, with 100% RDF and with 33% RDF were statistically at par with the most effective treatment [Table 4.12.1 (a)].

In the 2nd year the treatment combination 100% RDF with FC+VC registered significantly higher figure than in treatment 100% RDF with FC+VC (0.413 and 0.348 g respectively). Treatments 100% RDF alone, 33% RDF with FC+PM were statistically comparable with the most effective treatment. Treatment 33% RDF with FC+VC was at par with the second best treatment, i.e., 100% RDF alone (0.370 g).

Table 4.12.1(b) Effect of interaction of fertilizer levels and manurial forms on dry weight of blackgram (g/plant) at 30 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.888	1.167	1.149	1.068	0.502	0.611	0.691	0.601
F_1	1.136	1.136	1.114	1.129	0.835	0.865	0.896	0.865
F_2	1.132	1.391	1.146	1.223	0.893	0.882	0.944	0.906
Mean	1.052	1.231	1.136		0.743	0.786	0.844	
		SEd ± 0.138	CD(0.05) 0.277			SEd ± 0.090	CD(0.05) 0.181	

At 30 DAS in the 1st year treatment 100% RDF with FC+VC recorded significantly higher values than in control (1.391 and 0.888 g respectively). Treatment FC+VC alone (1.167 g) was statistically on par with the most effective treatment [Table 4.12.1 (b)].

In the 2nd year the treatment 100% RDF with FC+PM produced the maximum dry weight value which was significantly higher than treatment FC+PM alone (0.944 and 0.691g respectively). Treatments 33% RDF alone, with FC+PM and with FC+VC,

100% RDF alone and with FC+VC were statistically comparable. However, treatment FC+PM alone (0.691 g) was at par with treatment 33% RDF with FC+VC.

Table 4.12.1(c) Effect of interaction of fertilizer levels and manurial forms on dry weight of blackgram (g/plant) at 45 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	5.09	4.74	6.28	5.37	1.75	2.18	2.51	2.15
F_1	5.95	6.59	5.52	6.02	3.87	3.39	3.21	3.49
F_2	5.26	6.69	5.92	5.95	3.82	3.36	4.09	3.75
Mean	5.43	6.01	5.91		3.15	2.98	3.27	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.77	1.54			0.44	0.88	

At 45 DAS in the 1st year the treatment 100% RDF with FC+VC recorded significantly higher value than control [Table 4.12.1 (c)]. Treatments 33% with FC+VC and FC+PM alone were statistically at par with the most effective treatment.

In the 2nd year the treatment 100% RDF with FC+PM registered significantly higher value than treatment 33% RDF with FC+PM (4.087 and 3.357 g). However, treatments 33% RDF alone and with FC+VC, 100% RDF alone and with FC+VC were statistically on par with the most effective treatment.

Table 4.12.1(d) Effect of interaction of fertilizer levels and manurial forms on dry weight of blackgram (g/plant) at 60 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	13.27	14.85	13.89	14.00	5.92	6.47	8.03	6.81
F_1	14.95	19.39	16.05	16.80	10.08	14.55	15.38	13.34
F_2	16.97	15.34	15.03	15.78	14.72	12.77	10.91	12.80
Mean	15.06	16.53	14.99		10.24	11.26	11.44	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		2.34	4.69			1.64	3.28	

At 60 DAS in the 1st year the treatment 33% RDF with FC+VC recorded significantly higher value than treatment FC+PM alone. (19.39 and 13.89 g respectively).

In the 2nd year the treatment 33% RDFw ith FC+PM registered significantly higher value than treatment 100%RDF with FC+PM (15.38 and 10.91 g respectively). Treatments 100% RDF alone and with FC+VC and 33% RDF with FC+VC were statistically comparable with the most effective treatment [Table 4.12.1 (d)].

Table 4.12.1(e) **Effect of interaction of fertilizer levels and manurial forms on dry weight of blackgram (g/plant) at 75 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	24.12	27.52	31.61	27.75	10.74	12.05	18.99	13.93
F_1	27.88	28.49	28.10	28.16	27.74	29.37	30.34	29.15
F_2	26.21	23.22	34.77	28.07	29.91	24.04	29.27	27.74
Mean	26.07	26.41	31.49		22.80	21.82	26.20	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.04	8.11			3.63	7.29	

At 75 DAS in the 1st year treatment combination registered significantly higher value than the treatment 100% RDF alone [Table 4.12.1 (e)]. Treatments with 33% RDF combinations and FC+VC alone and FC+PM alone were at par with the most effective treatment.

In the 2nd year the treatment 33% RDF with FC+PM produced markedly higher figures than treatment FC+PM alone (30.34 and 18.99 g respectively). Treatments 100% RDF alone, with FC+PM and with FC+VC, 33% RDF alone and with FC+VC were comparable with treatment 33% RDF with FC+PM combination.

Table 4.12.1(f) **Effect of interaction of fertilizer levels and manurial forms on dry weight of blackgram (g/plant) at 90 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	37.41	45.58	47.71	43.57	14.30	22.14	28.39	21.61
F_1	48.17	52.81	45.95	48.98	33.91	38.31	30.41	34.21
F_2	51.65	48.99	57.96	52.87	33.70	31.78	35.18	33.55
Mean	45.74	49.13	50.54		27.30	30.74	31.33	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.34	8.71			4.54	9.11	

At 90 DAS in the 1st year the treatment 100% RDF with FC+PM recorded significantly higher value than treatment 100% RDF with FC+VC (57.96 and 48.99 g respectively). Treatments 33% RDF with FC+VC and 100% RDF alone were statistically comparable with the most effective treatment [Table 4.12.1 (f)]. However, treatments 100% RDF with FC+VC, 33% RDF alone and FC+PM were comparable with the 2nd best treatment combination, i.e., 33% RDF with FC+VC.

In the 2nd year the treatment 33% RDF with FC+VC recorded significantly higher value than treatment FC+PM alone (38.31 and 28.39 g respectively). Treatments

100% RDF alone, with FC+PM and with FC+VC, 33% RDF alone and with FC+PM were statistically on par with the most effective treatment.

4.4.1.5 Interaction effect due to fertilizer and biofertilizer and/or organic spray

Table 4.12.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of blackgram (g/plant) at 15 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.109	0.120	0.118	0.116	0.243	0.259	0.224	0.242
F_1	0.118	0.124	0.112	0.118	0.334	0.369	0.339	0.347
F_2	0.132	0.133	0.129	0.131	0.350	0.411	0.358	0.373
Mean	0.120	0.126	0.120		0.309	0.346	0.307	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.013	0.026			0.028	0.057	

In the 1st year at 15 DAS the interaction between fertilizer levels and biofertilizer and/or organic spray did not show marked influence on the dry matter accumulation of blackgram crop in the system [Table 4.12.2(a)]. However, the maximum and minimum values were observed in treatment 100% RDF with PSB+Rhz and control (0.133 and 0.109 g respectively).

In the 2nd year however, there was significant difference between the treatments and the highest value was registered in treatment 100% RDF with PSB+Rhz which was superior over treatment 100% RDF alone (0.411 and 0.350 respectively). Statistically par values were obtained in treatments 33% RDF with PSB+Rhz and 100% RDF with PSB+CU. Further, it was noted that treatments 100% RDF alone, 33% RDF alone and with PSB+CU were comparable with the second best combination, i.e., treatment 33% with PSB+Rhz.

Table 4.12.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of blackgram (g/plant) at 30 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.873	1.001	1.329	1.068	0.491	0.663	0.650	0.601
F_1	1.107	1.106	1.173	1.129	0.844	0.826	0.926	0.865
F_2	1.270	1.183	1.216	1.223	0.932	0.928	0.859	0.906
Mean	1.083	1.097	1.239		0.756	0.806	0.812	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.138	0.277			0.090	0.181	

At 30 DAS in the 1st year the treatment PSB+CU registered significantly higher figures than treatment PSB+Rhz alone (1.329 and 1.001 g respectively). Treatments 100% RDF alone, with PSB+CU and with PSB+Rhz, 33% RDF with PSB+CU were statistically on par with the most effective treatment [Table 4.12.2 (b)].

In the 2nd year the treatment 100% RDF alone registered significantly higher value than treatment PSB+Rhz alone (0.932 and 0.663 respectively). Treatments 100% RDF with PSB+Rhz and with PSB+CU, 33% RDF alone, with PSB+CU and with PSB+Rhz were statistically on par with the most effective treatment.

Table 4.12.2(c) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of blackgram (g/plant) at 45 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	4.95	5.74	5.42	5.37	2.04	2.27	2.13	2.15
F_1	5.74	6.59	5.73	6.02	3.18	3.39	3.91	3.49
F_2	6.27	6.06	5.54	5.95	3.37	4.30	3.59	3.75
Mean	5.66	6.13	5.56		2.87	3.32	3.21	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.77	1.54			0.44	0.88	

At 45 DAS in the 1st year treatment 33% RDF with PSB+Rhz combination obtained significantly higher value than control (6.587 and 4.954 g respectively). In the 2nd year treatment 100% RDF with PSB+Rhz registered significantly higher values than treatment 33% RDF with PSB+Rhz (4.298 and 3.389 g respectively). Treatments 33% RDF with PSB+CU and 100% RDF with PSB+CU were statistically at par with the most effective treatment [Table 4.12.2 (c)]. Further, it was noted that the treatments 33% RDF alone and with PSB+Rhz and treatment 100% RDF alone were comparable with the second best combination, i.e., 33% RDF with PSB+CU.

Table 4.12.2(d) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of blackgram (g/plant) at 60 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	10.37	16.95	14.69	14.00	6.21	5.72	8.50	6.81
F_1	17.24	16.10	17.04	16.79	12.43	14.24	13.34	13.34
F_2	14.52	17.84	14.98	15.78	10.91	14.35	13.14	12.80
Mean	14.04	16.96	15.57		9.85	11.44	11.66	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		2.34	4.69			1.64	3.28	

At 60 DAS in the 1st year the treatment 100% RDF with PSB+Rhz combination produced significantly higher values than control (17.84 and 10.37 g respectively). Treatments 33 % RDF alone, with PSB+CU and with PSB+Rhz and PSB+Rhz alone were on par with the most effective treatment [Table 4.12.2 (d)].

In the 2nd year the treatment 100% RDF with PSB+Rhz recorded significantly higher values than treatment 100% RDF alone. Treatments 33% RDF alone, with PSB+Rhz and with PSB+CU and 100% RDF with PSB+CU were statistically at par with the most effective treatment.

Table 4.12.2(e) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of blackgram (g/plant) at 75 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	24.41	30.57	28.27	27.75	13.27	13.10	15.41	13.93
F_1	23.23	28.81	32.43	28.16	24.07	32.97	30.41	29.15
F_2	26.76	26.49	30.95	28.07	27.61	26.10	29.52	27.74
Mean	24.80	28.62	30.55		21.65	24.06	25.11	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.04	8.11			3.63	7.29	

In the 1st year at 75 DAS [Table 4.12.2 (e)] the treatment combination 33% RDF with PSB+CU produced significantly higher values than treatment 33% RDF alone (32.43 and 23.23 respectively).

In the 2nd year the treatment 33% RDF with PSB+Rhz registered markedly higher figures than treatment 33% RDF alone (32.97 and 24.07 g respectively). Treatments 33% RDF with PSB+CU, 100% RDF alone, with PSB+CU and with PSB+Rhz were statistically comparable with the most effective treatment. Further, the treatment 33% RDF alone was at par with the 2nd best treatment combination, i.e., 33% RDF with PSB+CU (30.41 g).

Table 4.12.2(f) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of blackgram (g/plant) at 90 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	38.43	44.80	47.47	43.57	21.53	22.81	20.49	21.61
F_1	45.21	47.30	54.42	48.98	34.72	33.46	34.44	34.21
F_2	54.06	48.56	55.99	52.87	32.23	38.03	30.41	33.56
Mean	45.90	46.89	52.63		29.49	31.43	28.45	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.34	8.71			4.54	9.11	

At 90 DAS in the 1st year the treatment 100% RDF with PSB+CU recorded significantly higher values than treatment 33% RDF alone (55.99 and 45.21 g respectively). However, treatments 33% RDF with PSB+CU and with PSB+Rhz, 100% RDF alone and with PSB+Rhz and PSB+CU alone were statistically on par with the most effective treatment combination [Table 4.12.2 (f)].

In the 2nd year treatment 100% RDF with PSB+Rhz registered significantly higher value than treatment PSB+Rhz alone (38.03 and 22.81 g respectively). Treatments 33% RDF alone, with PSB+CU and with PSB+Rhz and 100% RDF alone were statistically at par with the most effective treatment.

4.4.1.5 Interaction effect due to manurial forms and biofertilizer and/or organic spray

Table 4.12.3(a) Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of blackgram (g/plant) at 15 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.104	0.121	0.123	0.116	0.242	0.352	0.296	0.297
C_1	0.117	0.122	0.121	0.120	0.356	0.360	0.306	0.340
C_2	0.139	0.134	0.114	0.129	0.330	0.327	0.320	0.326
Mean	0.120	0.126	0.120		0.309	0.346	0.307	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.013	0.026			0.028	0.057	

The interaction between manurial forms and biofertilizer and/or organic spray had shown affect on the dry weight values of blackgram crop in the system [Table 4.12.3 (a)]. At 15 DAS in the 1st year the treatment FC+PM alone registered significantly higher figure than control plot (0.139 and 0.104 g respectively). Treatment FC+PM with PSB+Rhz combination (0.134 g) was statistically comparable with the most effective treatment

In the 2nd year the treatment FC+VC with PSB+Rhz recorded higher dry weight value than treatment PSB+CU alone (0.360 and 0.296 g respectively). Treatments FC+VC alone and with PSB+CU, PSB+Rhz alone, FC+PM alone, with PSB+Rhz and with PSB+CU were statistically comparable with the most effective treatment.

At 30 DAS in the 1st year the treatment FC+VC with PSB+CU produced markedly higher values than the control plot (1.289 and 0.799 g respectively). Treatments PSB+CU alone, FC+VC alone and with PSB+Rhz, FC+PM alone and with

PSB+CU and PSB+Rhz alone were statistically comparable with the most effective treatment [Table 4.12.3 (b)].

Table 4.12.3(b) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of blackgram (g/plant) at 30 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.799	1.086	1.271	1.052	0.713	0.785	0.732	0.743
C_1	1.231	1.173	1.289	1.231	0.820	0.746	0.791	0.786
C_2	1.220	1.031	1.158	1.136	0.733	0.885	0.913	0.844
Mean	1.083	1.097	1.239		0.756	0.806	0.812	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.138	0.277			0.090	0.181	

In the 2nd year the treatment FC+PM with PSB+CU registered significantly higher dry weight value than control plot (0.931 and 0.713 g respectively).

Table 4.12.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of blackgram (g/plant) at 45 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	4.27	6.47	5.56	5.43	2.72	3.60	3.11	3.15
C_1	5.97	6.45	5.60	6.01	2.75	2.90	3.28	2.98
C_2	6.73	5.47	5.52	5.91	3.13	3.45	3.23	3.27
Mean	5.66	6.13	5.56		2.87	3.32	3.21	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.77	1.54			0.44	0.88	

At 45 DAS in the 1st year the treatment FC+PM alone registered significantly higher values than the control plot (6.73 and 4.27 g). Treatments PSB+Rhz, FC+VC alone and with PSB+Rhz were statistically at par with the most effective treatment [Table 4.12.3 (c)].

In the 2nd year the treatment PSB+Rhz registered significantly higher value than control plot (3.604 and 2.722 g respectively).

Table 4.12.3(d) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of blackgram (g/plant) at 60 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	10.29	19.53	15.37	15.06	7.84	10.58	12.31	10.24
C_1	16.81	16.65	16.11	16.52	9.34	13.03	11.42	11.26
C_2	15.03	14.72	15.22	14.99	12.38	10.69	11.25	11.44
Mean	14.04	16.97	15.57		9.85	11.43	11.66	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		2.34	4.69			1.64	3.28	

At 60 DAS in the 1st year the treatment PSB+Rhz recorded significantly higher values than in treatment FC+PM with PSB+Rhz (19.53 and 14.72 g respectively). Treatments with FC+VC combinations and FC+PM alone and with PSB+CU and PSB+CU alone were statistically at par with the most effective treatment [Table 4.12.3 (d)].

In the 2nd year the treatment FC+VC with PSB+Rhz registered significantly higher figures than treatment FC+VC alone (13.03 and 9.33 g respectively). Treatments FC+PM alone and with PSB+CU, PSB+CU alone and FC+VC with PSB+CU were statistically on par with the most effective treatment.

Table 4.12.3(e) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of blackgram (g/plant) at 75 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	19.87	30.91	27.43	26.07	17.85	23.25	27.29	22.80
C_1	23.59	27.73	27.91	26.41	19.46	22.94	23.06	21.82
C_2	30.94	27.23	36.30	31.49	27.63	25.97	25.00	26.20
Mean	24.80	28.62	30.55		21.65	24.05	25.12	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.04	8.11			3.63	7.29	

At 75 DAS in the 1st year the treatment FC+PM with PSB+CU registered significantly higher figure than in treatment FC+VC with PSB+CU (36.30 and 27.91 g respectively). Treatments FC+PM alone and PSB+Rhz were statistically comparable with the most effective treatment [Table 4.12.3 (e)].

In the 2nd year the treatment FC+PM alone produced markedly higher values than treatment FC+VC alone (27.63 and 19.46 g respectively). Treatments PSB+CU alone and FC+PM with PSB+Rhz were statistically at par with the most effective treatment.

Table 4.12.3(f) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of blackgram (g/plant) at 90 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	36.47	49.92	50.83	45.74	21.61	29.17	31.13	27.30
C_1	51.57	46.51	49.30	49.13	33.42	31.53	27.27	30.74
C_2	49.66	44.23	57.74	50.54	33.44	33.60	26.94	31.33
Mean	45.90	46.89	52.62		29.49	31.43	28.45	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.34	8.71			4.54	9.11	

In the 1st year at 90 DAS [Table 4.12.3 (f)] the treatment FC+PM with PSB+CU registered significantly higher than FC+VC with PSB+Rhz (57.74 and 46.51 g respectively). Treatments FC+VC alone and with PSB+CU, PSB+CU alone, PSB+Rhz alone and FC+PM alone were statistically at par with the most effective treatment. However, treatment FC+VC with PSB+Rhz was comparable with the 2nd best treatment, i.e., FC+VC alone (51.57 g).

In the 2nd year the treatment FC+PM with PSB+Rhz recorded significantly higher values than control (33.60 and 21.61 g respectively). Treatments FC+PM alone, FC+VC alone and with PSB+Rhz and PSB+CU were statistically comparable with the most effective treatment.

4.4.2 Nodulation pattern

4.4.2.1 Fertilizer levels

The nodulation of the blackgram crop in the system was significantly influenced by the different levels of fertilizers at 60 DAS in the 1st year and at 15, 30, 60 and 75 DAS during the 2nd year (Table 4.13). At all these stages the treatment 33% RDF was responsible for registering the maximum value, except at 30 DAS wherein the treatment 100% RDF caused the increased nodule count. However, statistical comparability with the other treatments i.e., 100% RDF and 33% RDF was observed at all these stages, except at 15 DAS during the 2nd year.

4.4.2.2 Manurial forms

The different forms of manurial combinations (Table 4.13) markedly influenced the nodule count at some of the stages in blackgram crop in the system. In the 1st year though significant differences were not apparent, the maximum values were registered in treatment FC+PM at 15, 30, 60 and 75 DAS and in treatment FC+VC at 45 DAS.

In the 2nd year at 15 DAS treatment FC+VC registered significantly higher value than the 0 level treatment (24.94 and 16.32 respectively). At 30 and 60 DAS during the 2nd year the treatment FC+PM recorded significantly higher figures (24.27 and 28.61 respectively) over 0 level combinations (16.70 and 14.42 respectively). However, it was noted that during all these three stages there was statistical comparability in treatment FC+PM (24.65) at 15 DAS and in treatment FC+VC (24.03 and 24.22 respectively) at 30 and 60 DAS.

Table 4.13 Effect of INM on nodule count of blackgram (number/plant) during 1997-98 and 1998-99

Factors	15 DAS		30 DAS		45DAS		60 DAS		75 DAS	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Fertilizer levels (F):										
F_0	14.87	20.24	22.67	17.58	47.01	19.82	42.72	13.99	7.72	8.54
F_1	13.96	24.28	22.78	22.80	60.68	20.16	51.43	30.16	7.36	25.22
F_2	14.75	21.38	22.51	24.63	64.46	26.85	48.26	23.11	7.25	19.13
	NS	*	NS	*	NS	NS	*	*	NS	*
Forms of manures (C):										
C_0	14.53	16.32	20.30	16.70	55.42	18.47	43.68	14.42	7.49	12.31
C_1	13.93	24.94	23.27	24.03	63.31	21.08	48.39	24.22	7.17	20.65
C_2	15.13	24.65	24.40	24.27	53.43	27.28	50.34	28.61	7.69	19.94
	NS	*	NS	*	NS	NS	NS	*	NS	NS
Biofertilizers &/or organic spray (B):										
B_0	15.75	21.40	21.03	22.16	56.37	21.48	48.30	16.32	6.78	14.34
B_1	13.34	21.39	24.27	21.98	69.94	24.21	46.59	22.78	6.36	19.87
B_2	14.49	23.11	22.67	20.87	45.85	21.15	47.52	28.16	9.20	18.68
	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEd ±	1.27	1.33	2.13	2.40	11.49	5.35	3.37	5.62	2.66	3.77
CD(0.05)	-	2.66	-	4.83	-	-	6.77	11.28	-	7.54
FxC FxB CxB:										
SEd ±	2.21	2.30	3.69	4.17	19.91	9.27	5.84	9.74	4.61	4.35
CD(0.05)	4.44	4.62	7.40	8.37	39.95	18.61	11.72	19.54	9.25	8.74

*Significant at P = 0.05 NS = non-significant

4.4.2.3 Biofertilizer and/or organic spray

Significant influence of biofertilizer and/or organic spray on the nodule count of blackgram was not observable at any stage in either of the experimental years (Table 4.13). The nodule count was highest in treatment PSB+Rhz at 30 and 45 DAS in the 1st year and at 45 and 75 DAS in the 2nd year.

4.4.2.4 Interaction effect due to fertilizer and manurial forms

Table 4.13.1(a) Effect of interaction of fertilizer levels and manurial forms on nodule count of blackgram (number/plant) at 15 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	13.80	14.33	16.47	14.87	11.44	22.70	26.59	20.24
F_1	14.09	14.09	13.71	13.96	17.44	29.15	26.26	24.28
F_2	15.69	13.36	15.20	14.75	20.07	22.96	21.11	21.38
Mean	14.53	13.93	15.13		16.32	24.94	24.65	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		2.22	4.45			2.30	4.62	

In the 1st year at 15 DAS there was no significant difference between treatments with regard to the nodulation pattern, due to the interaction of fertilizer levels and the manurial forms [Table 4.13.1(a)]. The maximum and minimum values were recorded respectively in treatments FC+PM alone (16.47) and 100% RDF with FC+VC (13.36).

However, in the 2nd year significant difference was observed, and treatment 33% RDF with FC+VC produced the highest count of nodules which was markedly higher than treatment 100% RDF with FC+VC (29.15 and 22.96 respectively). Treatments FC+PM alone and with 33% RDF were statistically at par with the most effective treatment.

Table 4.13.1(b) Effect of interaction of fertilizer levels and manurial forms on nodule count of blackgram (number/plant) at 30 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	20.29	21.81	25.92	22.67	10.74	19.81	22.20	17.58
F_1	18.07	25.95	24.33	22.78	19.55	23.74	25.11	22.80
F_2	22.55	22.03	22.96	22.51	19.81	28.55	25.51	24.62
Mean	20.30	23.26	24.40		16.70	24.03	24.27	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		3.69	7.41			4.17	8.38	

At 30 DAS in the 1st year the treatment 33% RDF with FC+VC registered the maximum nodule count which was significantly higher than the treatment 33% RDF alone (25.95 and 18.07 respectively). Treatment FC+PM (25.92) alone was significantly on par with the most effective treatment [Table 4.13.1(b)]. In the 2nd year the treatment 100% RDF with FC+VC registered markedly higher figures than 100% RDF alone (28.55 and 19.81 respectively). Treatments 100% RDF with FC+PM, 33% RDF with FC+PM and with FC+VC and FC+PM alone were statistically on par with the most effective treatment combination.

Table 4.13.1(c) **Effect of interaction of fertilizer levels and manurial forms on nodule count of blackgram (number/plant) at 45 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	51.37	31.00	58.66	47.01	22.59	15.63	21.26	19.83
F_1	50.62	81.37	50.03	60.67	14.41	28.96	17.11	20.16
F_2	64.26	77.55	51.58	64.46	18.40	18.66	43.48	26.85
Mean	55.42	63.31	53.42		18.47	21.08	27.28	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		19.91	39.96			9.28	18.61	

At 45 DAS in the 1st year the treatment 33% RDF with FC+VC produced significantly higher value than treatment FC+VC alone (81.37 and 31.00 respectively). Treatment 100% RDF with FC+VC (77.55) was statistically comparable with the most effective treatment [Table 4.13.1(c)].

In the 2nd year the treatment 100% RDF with FC+PM recorded significantly higher figure than in treatment 33% RDF alone.

Table 4.13.1(d) **Effect of interaction of fertilizer levels and manurial forms on nodule count of blackgram (number/plant) at 60 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	32.59	49.96	45.63	42.73	11.15	15.63	15.18	13.99
F_1	53.85	47.70	52.74	51.43	17.70	31.44	41.33	30.16
F_2	44.59	47.52	52.66	48.26	14.41	25.59	29.33	23.11
Mean	43.68	48.39	50.34		14.42	24.22	28.61	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		5.84	11.73			9.74	19.55	

At 60 DAS in the 1st year the treatment 33% RDF registered significantly higher value than control (53.85 and 32.59). All other treatments were statistically comparable with the most effective treatment [Table 4.13.1(d)].

In the 2nd year the treatment 33% RDF with FC+PM produced significantly higher nodule count than treatment 33% RDF alone (41.33 and 17.70). Treatment 33% RDF with FC+VC was statistically comparable with the most effective treatment. At 75 DAS in the 1st year no significant difference between the treatments was observed with regard to nodule count [Table 4.13.1(e)]. The maximum and minimum figures were registered in treatments FC+PM with 33% RDF and 100% RDF respectively (9.47 and 5.25).

Table 4.13.1(e) **Effect of interaction of fertilizer levels and manurial forms on nodule count of blackgram (number/plant) at 75 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	9.14	5.70	8.33	7.73	8.66	10.48	6.48	8.54
F_1	5.96	6.66	9.48	7.37	19.00	24.26	32.40	25.22
F_2	7.37	9.15	5.26	7.26	9.26	27.22	20.92	19.13
Mean	7.49	7.17	7.69		12.31	20.65	19.93	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.61	9.26			7.55	15.15	

In the 2nd year the treatment 33% RDF with FC+PM recorded significantly higher value than the treatment FC+VC alone (32.40 and 10.48 respectively). Treatments FC+VC with 100% RDF and with 33% RDF were statistically comparable with the most effective treatment.

4.4.2.5 Interaction effect due to fertilizer levels and biofertilizer and/or organic spray

Table 4.13.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on nodule count of blackgram (number/plant) at 15 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	15.89	12.91	15.80	14.87	19.59	18.85	22.29	20.24
F_1	15.00	12.93	13.96	13.96	23.00	24.18	25.67	24.28
F_2	16.36	14.18	13.71	14.75	21.63	21.15	21.37	21.38
Mean	15.75	13.34	14.49		21.41	21.39	23.11	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		2.22	4.45			2.30	4.62	

The interaction between fertilizer levels and manurial forms did not show any significant effect on the nodulation pattern at 15 DAS in the 1st year [Table 4.13.2(a)]. The maximum and minimum figures were registered in treatment 100% RDF alone and PSB+Rhz alone respectively (16.36 and 12.91).

In the 2nd year however, significant differences were noticed and treatment 33% RDF with PSB+CU (25.67) recorded the highest nodule count. Statistically par values were obtained in treatment 33% RDF with PSB+Rhz (24.18).

At 30 DAS in the 1st year no significant difference between the nodule count values of the treatments were observed [Table 4.13.2(b)]. The minimum and maximum values were recorded respectively in treatment 33% RDF alone and with PSB+CU (18.40 and 25.66).

Table 4.13.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on nodule count of blackgram (number/plant) at 30 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	22.37	22.88	22.77	22.67	15.37	16.79	20.59	17.58
F_1	18.40	24.29	25.66	22.78	22.14	23.63	22.63	22.80
F_2	22.33	25.63	19.59	22.52	28.96	25.52	19.40	24.63
Mean	21.03	24.27	22.67		22.16	21.98	20.87	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		3.69	7.41			4.17	8.38	

In the 2nd year the treatment 100% RDF alone recorded significantly higher value than treatment PSB+CU alone (28.96 and 20.59 respectively). Treatment 100% RDF with PSB+Rhz (25.52) was statistically on par with the most effective treatment.

Table 4.13.2(c) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on nodule count of blackgram (number/plant) at 45 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	51.48	50.00	39.55	47.01	13.15	30.07	16.26	19.83
F_1	40.03	78.59	63.40	60.67	17.85	26.74	15.89	20.16
F_2	77.59	81.22	34.58	64.46	33.44	15.81	31.29	26.85
Mean	56.37	69.94	45.84		21.48	24.21	21.15	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		19.91	39.96			9.28	18.61	

At 45 DAS in the 1st year treatment 100% RDF with PSB+Rhz recorded markedly higher value than treatment 33% RDF alone (81.22 and 40.03). Treatments 33% RDF with PSB+Rhz and 100% RDF alone (78.59 and 77.59 respectively) were statistically comparable with the most effective treatment [Table 4.13.2(c)].

In the 2nd year the treatment 100% RDF alone registered significantly higher figures than the control plot (33.44 and 13.15 respectively).

At 60 DAS [Table 4.13.2(d)] in the 1st year the treatment 33% RDF alone recorded significantly higher value than the treatment PSB+CU alone (56.22 and 44.07 respectively).

Table 4.13.2(d) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on nodule count of blackgram (number/plant) at 60 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	42.03	42.07	44.07	42.72	9.52	16.22	16.22	13.99
F_1	56.22	50.89	47.18	51.43	18.48	25.74	46.26	30.16
F_2	46.66	46.81	51.29	48.25	20.96	26.37	22.00	23.11
Mean	48.30	46.59	47.51		16.32	22.78	28.16	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		5.84	11.73			9.74	19.55	

In the 2nd year treatment 33% RDF with PSB+CU combination (46.26) registered highly significant values over all the treatments and control plot (9.51).

Table 4.13.2(e) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on nodule count of blackgram (number/plant) at 75 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	5.00	9.66	8.52	7.73	2.59	11.41	11.63	8.54
F_1	6.89	4.59	10.63	7.37	21.85	29.63	24.18	25.22
F_2	8.48	4.85	8.44	7.26	18.59	18.59	20.22	19.13
Mean	6.79	6.37	9.20		14.34	19.88	18.68	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.61	9.26			7.55	15.15	

At 75 DAS [Table 4.13.2(e)] in the 1st year no significant difference between the nodule count values were observed as a result of interaction of fertilizer levels and biofertilizer and/or organic spray. The maximum and minimum values were recorded in treatment 33% RDF with PSB+CU and 33% RDF with PSB+Rhz respectively (10.63 and 4.59).

In the 2nd year the treatment 33% RDF with PSB+Rhz registered significantly higher values than treatment PSB+CU alone (29.63 and 11.63). Treatments 33% alone, with PSB+CU, 100% RDF alone, with PSB+CU and with PSB+Rhz were statistically comparable with the most effective treatment.

4.4.2.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

In the 1st year at 15 DAS [Table 4.13.3(a)] no significant difference was observed between the nodule count values as a result of interaction of manurial forms and biofertilizer and/or organic spray. The maximum and minimum values recorded respectively in treatment FC+PM alone and PSB+Rhz alone (16.78 and 12.31).

Table 4.13.3(a) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on nodule count of blackgram (number/plant) at 15 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	16.09	12.31	15.18	14.53	16.07	16.55	16.33	16.32
C_1	14.38	13.73	13.67	13.93	23.00	22.40	29.40	24.93
C_2	16.78	13.98	14.62	15.13	25.14	25.22	23.59	24.65
Mean	15.75	13.34	14.49		21.40	21.39	23.11	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		2.22	4.45			2.30	4.62	

In the 2nd year however, the treatment FC+VC with PSB+CU registered significantly higher value than treatment FC+PM with PSB+CU (29.40 and 23.59). Treatments FC+PM alone and with PSB+Rhz (25.22 and 25.14 respectively) were statistically on par with the most effective treatment. Further, treatments FC+PM with PSB+CU, FC+VC alone and with PSB+Rhz were also comparable with the second best treatment, i.e., FC+PM with PSB+Rhz (25.22).

Table 4.13.3(b) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on nodule count of blackgram (number/plant) at 30 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	17.44	18.92	24.55	20.30	18.11	17.55	14.44	16.70
C_1	24.04	26.40	19.36	23.27	28.33	21.59	22.18	24.03
C_2	21.63	27.48	24.11	24.41	20.03	26.79	26.00	24.27
Mean	21.04	24.27	22.67		22.16	21.98	20.87	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		3.69	7.41..			4.17	8.38	

At 30 DAS [Table 4.13.3(b)] in the 1st year the treatment FC+PM with PSB+Rhz registered significantly higher figures than treatment FC+VC with PSB+CU (27.48 and 19.36 respectively). Treatment FC+VC with PSB+Rhz (26.40) was statistically at par with the most effective treatment.

In the 2nd year treatment FC+VC alone recorded significantly higher than control plot (28.33 and 18.11). Treatments FC+PM with PSB+Rhz and with PSB+CU (26.79 and 26.00 respectively) were statistically on par with the most effective treatment.

At 45 DAS [Table 4.13.3(c)] in the 1st year treatment FC+VC with PSB+Rhz registered significantly higher nodule count values than control (99.03 and 54.96 respectively).

Table 4.13.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on nodule count of blackgram (number/plant) at 45 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	54.96	64.26	47.03	55.42	16.14	23.03	16.22	18.46
C_1	46.59	99.03	44.29	63.30	16.26	23.22	23.77	21.08
C_2	67.55	46.52	46.21	53.43	32.03	26.37	23.44	27.28
Mean	56.37	69.94	45.84		21.48	24.21	21.14	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		19.91	39.96			9.28	18.61	

In the 2nd year there was no significant difference in the nodule count values between the treatment as a result of interaction between manurial forms and biofertilizer and/or organic spray. The maximum and minimum values were produced respectively by treatment FC+PM and control (32.03 and 16.14).

Table 4.13.3(d) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on nodule count of blackgram (number/plant) at 60 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	39.29	46.78	44.96	43.68	13.89	14.07	15.29	14.42
C_1	55.92	44.40	44.85	48.39	15.66	23.22	33.78	24.22
C_2	49.70	48.59	52.74	50.34	19.41	31.03	35.40	28.61
Mean	48.30	46.59	47.52		16.32	22.77	28.16	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		5.84	11.73			9.74	19.55	

At 60 DAS [Table 4.13.3(d)] the treatment FC+VC alone recorded significantly higher value than control plot (55.92 and 39.29 respectively). Treatment FC+PM with PSB+CU combination (52.74) was comparable with the most effective treatment.

In the 2nd year treatment FC+VC with PSB+CU registered significantly higher nodule count figures than treatment FC+VC alone (35.40 and 15.66 respectively).

Treatment FC+VC with PSB+CU combination (33.78) was statistically on par with the most effective treatment.

Table 4.13.3(e) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on nodule count of blackgram (number/plant) at 75 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	7.07	5.37	10.03	7.49	6.52	12.89	17.52	12.31
C_1	6.96	4.70	9.85	7.17	17.52	20.96	23.48	20.65
C_2	6.33	9.03	7.70	7.69	19.00	25.78	15.04	19.94
Mean	6.79	6.37	9.19		14.35	19.88	18.68	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		4.61	9.26			7.55	15.15	

At 75 DAS [Table 4.13.3(e)] in the 1st year no significant difference between the nodule count values as a result of interaction of manurial forms and biofertilizer and/or organic spray was observed. The maximum and minimum figures recorded were respectively in treatments PSB+CU alone and FC+VC with PSB+Rhz (10.03 and 4.70).

In the 2nd year however, significant difference was observed, and treatment FC+PM with PSB+Rhz registered the highest value followed by treatment FC+VC with PSB+CU, both of which were statistically at par (25.78 and 23.48 respectively).

4.4.3 Yield attributes and yield

4.4.3.1 Fertilizer levels

Statistical analysis of the data pertaining to certain yield attributes of blackgram revealed that the levels of fertilizer influenced these parameters significantly (Table 4.14). The pod count per plant in the 1st year was significantly higher in treatment 33% RDF level (51.43), and in the 2nd year in treatment 100% RDF level (44.09) than in the 0 level combinations.

The data on test weight and seed yield in the 1st year showed no significant difference. However, the highest figures were registered in the treatment 100% RDF level (32.63 g and 3629.00 kg ha^{-1} respectively). In the 2nd year the test weight and seed yield (38.20 g and 2423.00 kg ha^{-1} respectively) were significantly higher in treatment 33% RDF than in treatment with 0 level combination. Statistical comparability between the two levels, *viz.*, 100% and 33% RDF was observed in both the years.

4.4.3.2 Manurial forms

Significant differences between treatments with regard to yield and certain yield attributes were not perceivable as a result of the different forms of manure (Table 4.14). However, the maximum figures of pod count and test weight in both the years were registered in treatment FC+PM. The highest value of seed yield was recorded in treatment FC+VC in the 1st year, and in the 0 level combination in the 2nd year.

4.4.3.3 Biofertilizer and/or organic spray

In both the years, the yield attribute test weight was significantly influenced by the treatment PSB+CU and registered higher values (33.06 and 38.17 in 1st and 2nd year respectively) than in treatment PSB+Rhz (31.57 and 37.39 in 1st and 2nd year respectively). Though the pod count and seed yield did not show significant difference, either of the treatments PSB+CU or PSB+Rhz were responsible for the highest values, except the pod count in the 1st year (Table 4.14).

Table 4.14 Effect of INM on yield attributes of blackgram during 1997-98 and 1998-99

Factors	Pods/plant		Test weight (g)		Seed yield (kg ha^{-1})	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Fertilizer levels (F):						
F_0	42.69	21.93	31.41	36.71	3526.00	1590.00
F_1	51.43	40.67	32.61	38.20	3454.00	2423.00
F_2	48.26	44.09	32.63	37.89	3629.00	2339.00
	*	*	NS	*	NS	*
Forms of manure (C):						
C_0	43.68	36.39	31.65	37.53	3430.00	2252.00
C_1	48.39	32.27	32.28	37.54	3619.00	1945.00
C_2	50.30	38.02	32.72	37.73	3561.00	2155.00
	NS	NS	NS	NS	NS	NS
Biofertilizer &/or organic spray (B):						
B_0	48.27	33.32	32.02	37.24	3338.00	2111.00
B_1	46.59	34.78	31.57	37.39	3679.00	2064.00
B_2	47.52	38.58	33.06	38.17	3592.00	2177.00
	NS	NS	*	*	NS	NS
SEd $\pm$	3.37	3.09	0.568	0.355	162.35	237.83
CD(0.05)	6.77	6.21	1.14	0.714	-	477.24
FxC FxB CxB:						
SEd $\pm$	5.85	5.36	0.985	0.616	281.20	411.90
CD(0.05)	11.74	10.76	1.976	1.230	564.36	826.68

*Significant at P = 0.05 NS = non-significant

4.4.3.4 Interaction effect due to fertilizer levels and manurial forms

In the 1st year the interaction between the fertilizer levels and manurial forms [Table 4.14.1(a)] produced significantly higher value in treatment 33% RDF alone than

in control plot (53.85 and 32.59 respectively). All other treatment combinations were statistically comparable with the most effective treatment.

Table 4.14.1(a) **Effect of interaction of fertilizer levels and manurial forms on pod count of blackgram (number/plant) at harvest**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	32.59	49.96	45.51	42.68	17.06	24.11	24.61	21.92
F_1	53.85	47.70	52.74	51.43	47.17	40.33	34.50	40.66
F_2	44.59	47.52	52.66	48.25	44.96	32.36	54.94	44.08
Mean	43.67	48.59	50.30		36.39	32.26	38.01	
		SEd ± 5.85	CD(0.05) 11.74			SEd ± 5.36	CD(0.05) 10.77	

In the 2nd year the treatment 100% RDF with FC+PM registered significantly higher pod count than treatment 33% RDF with FC+VC treatment combination (54.94 and 40.33 respectively). Treatments 33% RDF alone and 100% RDF alone 47.17 and 44.96 respectvely) were statistically at par with the most effective treatment.

Table 4.14.1(b) **Effect of interaction of fertilizer levels and manurial forms on test weight of blackgram (g) at harvest**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	30.28	31.78	32.17	31.41	35.98	36.73	37.42	36.71
F_1	31.72	32.78	33.00	32.61	38.76	37.43	38.42	38.20
F_2	32.94	32.28	32.67	32.63	37.84	38.46	37.37	37.89
Mean	31.65	32.28	32.72		37.53	37.54	37.74	
		SEd ± 0.99	CD(0.05) 1.98			SEd ± 0.62	CD(0.05) 1.24	

In the 1st year the test weight values were significantly higher in treatments 33% RDF with FC+PM and with FC+VC, 100% RDF alone, with FC+VC and with FC+PM [Table 4.14.1(b)]. These were statistically comparable and were superior to the control plot. The maximum and minimum values were recorded respectively in treatment 33% RDF with FC+PM combination and control (33 and 30.28 g respectively).

In the 2nd year the treatments 33% RDF alone and with FC+PM, 100% RDF alone and with FC+VC were significantly above treatment FC+VC alone with regard to the test weight values. The maximum and minimum values respectively were in treatment 33% RDF alone and control (38.76 and 35.98 g respectively).

Table 4.14.1(c) **Effect of interaction of fertilizer levels and manurial forms on seed yield of blackgram (kg ha^{-1}) at harvest**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	3324.00	3437.00	3816.00	3525.67	1482.00	1444.00	1844.00	1590.00
F_1	3402.00	3705.00	3256.00	3454.33	2556.00	2345.00	2367.00	2422.67
F_2	3562.00	3714.00	3610.00	3628.67	2717.00	2046.00	2254.00	2339.00
Mean	3429.33	3618.67	3560.67		2251.67	1945.00	2155.00	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		281.20	564.37			411.90	826.68	

In the 1st year the seed yield values did not show any significant difference between the treatments as a result of interaction of fertilizer levels and manurial forms [Table 4.14.1(c)]. The maximum and minimum values were recorded respectively in treatments FC+PM alone and 33% RDF with FC+PM (3816.00 and 3256.00 kg ha^{-1})

In the 2nd year the interaction between these factors was not significant. However, the maximum seed yield value was registered in treatment 100% RDF alone followed by 33% RDF alone, with FC+PM and with FC+VC (2717.00, 2556.00 and 2367.00 kg ha^{-1} respectively).

4.4.3.5 Interaction effect due to fertilizer levels and biofertilizer and/or organic spray

Table 4.14.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on pod count of blackgram (number/plant) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	41.92	42.07	44.07	42.69	23.78	20.56	21.44	21.93
F_1	56.22	50.89	47.18	51.43	32.67	40.28	49.06	40.67
F_2	46.66	46.81	51.29	48.25	43.52	43.50	45.25	44.09
Mean	48.27	46.59	47.51		33.32	34.78	38.58	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		5.85	11.74			5.36	10.77	

In the 1st year the pod count value was significantly higher in treatment 33% RDF alone than in treatment PSB+CU alone (56.22 and 44.07 respectively). The minimum figure of 41.92 was recorded in the 0 level combinations [Table 4.14.2(a)].

In the 2nd year the treatment combination 100% RDF with PSB+CU recorded significantly higher pod count value than in treatment 33% RDF with PSB+Rhz (54.94 and 40.33 respectively). The treatments 33% RDF alone and 100% RDF alone were comparable (47.17 and 44.96 respectively) with the most effective treatment.

Table 4.14.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on test weight of blackgram (g) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	30.50	31.61	32.11	31.41	35.28	37.76	37.09	36.71
F_1	32.56	31.67	33.61	32.61	37.99	36.43	40.17	38.20
F_2	33.00	31.44	33.44	32.63	38.44	37.99	37.23	37.89
Mean	32.02	31.57	33.05		37.24	37.39	38.16	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.99	1.98			0.62	1.24	

In the 1st year the test value of seeds of blackgram was significantly higher in treatment 33% RDF with PSB+CU than in treatment 100% RDF with PSB+Rhz (33.61 and 31.44). Treatments 100% RDF alone and with PSB+CU and 33% RDF alone were statistically on par with the treatment with the highest value [Table 4.14.2(b)].

In the 2nd year the treatment combination 33% RDF with PSB+CU registered markedly higher test weight figures in treatment 33% RDF with PSB+CU over treatment 100% RDF alone (40.17 and 38.44 g respectively). However, treatments 100% RDF with PSB+Rhz and 33% RDF alone (37.99 in both) were statistically comparable with the treatment 100% RDF alone effective treatment.

Table 4.14.2(c) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on seed yield of blackgram (kg ha^{-1}) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	3161.00	3762.00	3655.00	3526.00	1668.00	1518.00	1585.00	1590.33
F_1	3293.00	3411.00	3659.00	3454.33	2596.00	2061.00	2612.00	2423.00
F_2	3561.00	3864.00	3462.00	3629.00	2069.00	2613.00	2335.00	2339.00
Mean	3338.33	3679.00	3592.00		2111.00	2064.00	2177.33	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		281.20	564.37			411.90	826.68	

In the 1st year the seed yield of blackgram was significantly higher in treatment 100% RDF with PSB+Rhz than in treatment 33% RDF alone (3864.00 and 3293.00 kg ha^{-1}). Treatment PSB+Rhz alone (3762.00 kg ha^{-1}) was on par with the most effective treatment [Table 4.14.2(c)].

In the 2nd year the treatment 100% RDF with PSB+Rhz registered significantly higher seed yield figures than control plot (2613.00 and 1668.00 kg ha^{-1} respectively). Treatments 33% RDF alone, and with PSB+CU (2596.00 and 2612.00 kg ha^{-1} respectively) were statistically on par with the treatment with highest yield.

4.4.3.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

Table 4.14.3(a) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on pod count of blackgram (number/plant) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	39.29	46.78	44.96	43.68	28.30	37.44	43.44	36.39
C_1	55.92	44.40	44.85	48.39	32.17	28.61	36.03	32.27
C_2	49.59	48.59	52.74	50.31	39.50	38.28	36.28	38.02
Mean	48.27	46.59	47.52		33.32	34.78	38.58	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		5.85	11.74			5.36	10.77	

In the 1st year the pod count value as affected by interaction of manurial forms and biofertilizer and/or organic spray showed significantly higher value in treatment FC+VC alone (55.92) followed by treatment FC+PM with PSB+CU (52.74), both of which were statistically comparable [Table 4.14.3(a)].

In the 2nd year the treatment PSB+CU alone registered significantly higher pod count values than treatment FC+VC alone (43.44 and 32.17 respectively). Treatment FC+PM alone (39.50) was statistically comparable with the most effective treatment.

Table 4.14.3(b) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on test weight of blackgram (g) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	31.00	31.44	32.50	31.65	35.76	38.11	38.71	37.53
C_1	32.39	31.11	33	32.28	37.97	36.66	37.99	37.54
C_2	32.67	32.17	33	32.72	37.99	37.41	37.79	37.73
Mean	32.02	31.57	33.05		37.24	37.39	38.16	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.99	1.98			0.62	1.24	

In the 1st year the test weight values [Table 4.14.3(b)] in treatment combinations PSB+CU with FC+PM and with FC+VC registered significantly higher than control plot (33 in both and 31.00 respectively).

In the 2nd year the treatment PSB+CU alone registered significantly higher test weight values than treatment combination FC+PM with PSB+Rhz (38.71 and 37.41 g respectively). Treatments PSB+Rhz alone, FC+PM alone and with PSB+CU, FC+VC alone and with PSB+CU were statistically on par with the most effective treatment.

Table 4.14.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on seed yield of blackgram (kg ha^{-1}) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	2922.00	3773.00	3594.00	3429.67	1628.00	2639.00	2488.00	2251.67
C_1	3507.00	3649.00	3700.00	3618.67	1886.00	1751.00	2198.00	1945.00
C_2	3585.00	3616.00	3481.00	3560.67	2819.00	1802.00	1846.00	2155.67
.Mean	3338.00	3679.33	3591.67		2111.00	2064.00	2177.33	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		281.20	564.37			411.90	826.68	

The seed yield of blackgram in the 1st year as affected by the interaction of manurial forms and biofertilizer and/or organic spray showed significantly higher values in treatment PSB+Rhz alone than control plot (3773.00 and 2922.00 kg ha^{-1}). Treatments FC+VC alone, with PSB+CU and with PSB+Rhz, FC+PM alone and with PSB+Rhz and PSB+CU alone were statistically at par with the most effective treatment [Table 4.14.3(c)].

In the 2nd year the treatment FC+PM alone registered markedly higher seed yield value than treatment FC+VC alone (2819.00 and 1886.00 kg ha^{-1}). Treatments PSB+CU alone and PSB+Rhz alone were statistically comparable with the most effective treatment.

4.4.4 Post-cropping status of soil

4.4.4.1 Fertilizer levels

The post-cropping analyses of the soil in the system showed marked influence on most of the parameters. Significant differences in the pH values due to the treatments were not apparent (Table 4.15). However, the EC_{25} was significantly lower in both the years in plots with treatment 33% RDF level (0.18 and 0.17 dS m^{-1} respectively) than in the 0 level RDF treated plots (0.40 and 0.21 dS m^{-1} respectively). Statistically comparable figures were recorded in the 2nd year in plots with 100% RDF treatment (0.18 dS m^{-1}).

The organic carbon status was markedly higher in the 1st year in plots with 33% RDF than the 0 level plots (0.66 and 0.34% respectively). However, in the second year there was no significant difference in the value obtained.

Table 4.15 Effect of blackgram cropping under INM system on the Physico-chemical properties of the soil

Factors	pH		EC_{25}		Organic Carbon (%)		Available Phosphorus (kg ha^{-1})		Available Potassium (kg ha^{-1})	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Levels of fertilizer (F):										
F_0	7.25	7.88	0.40	0.21	0.23	0.34	9.51	18.41	369.20	262.60
F_1	7.17	7.87	0.18	0.17	0.66	0.30	20.56	22.63	511.60	268.10
F_2	7.23	7.85	0.20	0.18	0.57	0.33	37.59	30.44	611.80	333.40
	NS	NS	*	*	*	NS	*	*	*	*
Forms of manure (C):										
C_0	7.27	7.87	0.31	0.21	0.36	0.27	15.74	18.04	391.70	257.40
C_1	7.20	7.87	0.25	0.17	0.49	0.33	22.96	23.19	516.30	274.10
C_2	7.18	7.86	0.22	0.17	0.61	0.38	28.96	30.26	584.70	332.50
	NS	NS	*	*	*	*	*	*	*	*
Biofertilizer &/or organic spray (B):										
B_0	7.28	7.87	0.29	0.22	0.44	0.28	20.56	20.15	465.90	258.30
B_1	7.20	7.84	0.25	0.17	0.49	0.38	22.22	22.93	504.00	285.00
B_2	7.17	7.88	0.24	0.17	0.53	0.32	24.89	28.41	522.70	320.90
	NS	NS	*	*	*	*	*	NS	*	*
SEd ±	0.043	0.023	0.006	0.008	0.008	0.040	0.397	3.840	15.770	9.810
CD(0.05)	-	-	0.0125	0.0163	0.017	0.080	0.790	7.720	31.650	19.690
FxC FxB CxB:										
SEd ±	0.075	0.040	0.010	0.014	0.015	0.069	0.680	6.660	27.330	17.000
CD(0.05)	0.150	0.081	0.021	0.028	0.030	0.138	1.380	13.380	54.850	34.110

*Significant at P = 0.05 NS = non-significant

In both the years the available phosphorus and potassium levels were significantly higher in plots with 100% RDF treatment (37.59 and 611.80 respectively kg ha^{-1} in the 1st year and 30.44 and 333.40 kg ha^{-1} respectively in the 2nd year) than in plots with 33% RDF level.

4.4.4.2 Manurial forms

The soil pH values in the post cropping analysis showed no apparent difference due to the varying manurial forms (Table 4.15). EC_{25} values were markedly lower in plots with FC+PM treatment (0.22 dS m^{-1}) in the 1st year and in the treatments FC+PM and FC+VC (0.17 dS m^{-1} in both treatments) in the 2nd year.

The organic carbon, available phosphorus and potassium in both the years were significantly higher in treatment FC+PM (0.61%, 28.96 and 584.70 kg ha^{-1} respectively in the 1st year and 0.38%, 30.26 and 332.50 kg ha^{-1} respectively in the 2nd year). Statistical comparability was noticed in treatment FC+VC with regard to percentage organic carbon and available phosphorus (0.33% and 23.19 kg ha^{-1} respectively) in the 2nd year.

4.4.4.3 Biofertilizer and/or organic spray

The pH analyses in both the years were not significantly influenced by any of the treatments of biofertilizer and/or organic spray (Table 4.15). However, the treatment PSB+Rhz (0.24 dS m^{-1}) in the 1st year and treatments PSB+CU and PSB+Rhz (0.17 dS m^{-1} in both) in the 2nd year registered markedly lower values of EC_{25}. Statistical comparability was noticed in treatment PSB+Rhz in the 1st year (0.25 dS m^{-1}).

The analyses of organic carbon (0.53%) in the 1st year, available phosphorus and potassium (24.89 and 522.70 kg ha^{-1} respectively in the 1st year and 28.41 and 320.90 kg ha^{-1} respectively in the 2nd year) in both the years were significantly higher in treatment PSB+CU. The percentage organic carbon was markedly higher in treatment PSB+Rhz (0.38) in the 2nd year. Statistical comparability was noticed in treatment PSB+Rhz in the 1st year with reference to available phosphorus, and treatment PSB+CU in the 2nd year with reference to organic carbon.

4.4.4.4 Interaction effect due to fertilizer levels and manurial forms

The EC_{25} value in the 1st year was significantly lower [Table 4.15.1(a)] in treatment combination 33% RDF with FC+PM than treatment 100% RDF alone (0.158 and 0.216 dS m^{-1}). Statistically comparable figures were obtained in treatment 33% RDF with FC+VC combination (0.180 dS m^{-1}).

Table 4.15.1(a) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (blackgram) status of EC_{25} (dS m^{-1}) of soil**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.501	0.397	0.312	0.403	0.270	0.187	0.190	0.216
F_1	0.219	0.180	0.158	0.186	0.172	0.163	0.176	0.170
F_2	0.216	0.199	0.190	0.202	0.203	0.177	0.172	0.184
Mean	0.312	0.259	0.220		0.215	0.176	0.179	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.011	0.022			0.014	0.028	

In the 2nd year treatment 33% with FC+VC combination recorded significantly lower values of EC_{25} than treatment 100% RDF alone (0.163 and 0.203 dS m^{-1} respectively). Treatments 33% RDF alone and 100% RDF with FC+PM were statistically on par with the most effective treatment.

Table 4.15.1(b) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (blackgram) status of organic carbon (%) of soil**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.183	0.222	0.310	0.239	0.344	0.320	0.380	0.348
F_1	0.466	0.691	0.829	0.662	0.198	0.370	0.360	0.309
F_2	0.447	0.577	0.693	0.572	0.288	0.319	0.400	0.336
Mean	0.365	0.497	0.611		0.277	0.336	0.380	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.015	0.030			0.069	0.139	

In the 1st year the interaction between fertilizer levels and manurial forms produced significantly higher [Table 4.15.1(b)] organic carbon in the soil than treatment 100% RDF with FC+PM combination (0.829 and 0.693% respectively).

In the 2nd year the treatment 100% RDF with FC+PM registered significantly higher values than the control plot (0.400 and 0.198% respectively). Statistical comparability was noticed in treatments FC+PM alone, 33% RDF with FC+VC and with FC+PM combination.

In the 1st year the available phosphorus figures were highly significant [Table 4.15.1(c)] in treatment 100% RDF with FC+PM combination (47.00 kg ha^{-1}). The minimum value of 6.33 kg ha^{-1} was noted in control plot.

Table 4.15.1(c) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (blackgram) status of available P_2O_5 (kg ha^{-1}) of soil**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	6.33	8.67	13.56	9.52	13.89	16.78	24.56	18.41
F_1	11.11	24.22	26.33	20.55	17.44	22.89	27.56	22.63
F_2	29.78	36.00	47.00	37.59	22.78	29.89	38.67	30.45
Mean	15.74	22.96	28.96		18.04	23.19	30.26	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.69	1.38			6.67	13.38	

In the 2nd year there was signficant difference between the treatments as a result of the interaction of fertilizer levels and manurial forms. The maximum and minimum values were registered respectively in the treatment 100% RDF with FC+PM combination and control plot (38.67 and 13.89 kg ha^{-1} respectively). Statistical comparability was noticed in treatments 100% RDF with FC+VC and 33% RDF with FC+PM combination (29.89 and 27.56 kg ha^{-1} respectively).

Table 4.15.1(d) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (blackgram) status of available K_2O (kg ha^{-1}) of soil**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	299.90	381.60	426.10	369.20	259.00	275.00	253.70	262.57
F_1	457.10	495.10	582.70	511.63	252.20	270.00	282.10	268.10
F_2	418.10	672.10	745.20	611.80	261.10	277.40	461.80	333.43
Mean	391.70	516.27	584.67		257.43	274.13	332.53	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		27.33	54.85			17.00	34.12	

In the 1st year the treatment 100% RDF with FC+PM combination registered significantly higher values of soil available phosphorus [Table 4.15.1(d)] than treatment 100% RDF with FC+VC combination (745.20 and 672.10 kg ha^{-1} respectively), which in turn was significantly higher than treatment 33% RDF with FC+PM combination (582.70 kg ha^{-1}). However, the treatment 33% RDF with FC+PM was superior to other treatments.

In the 2nd year the treatment 100% RDF with FC+PM combination (461.80 kg ha^{-1}) registered highly significant values over all the other treatments. The minimum value of 252.2 kg ha^{-1} was recorded in the control plot.

4.4.4.5 Interaction effect due to fertilizer levels and biofertilizer and/or organic spray

Table 4.15.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (blackgram) status of EC_{25} (dS m^{-1}) of soil**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.468	0.386	0.357	0.403	0.290	0.176	0.181	0.216
F_1	0.200	0.186	0.171	0.186	0.166	0.177	0.169	0.170
F_2	0.203	0.202	0.199	0.201	0.214	0.163	0.174	0.184
Mean	0.290	0.258	0.242		0.223	0.172	0.175	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.011	0.022			0.014	0.028	

In the 1st year the EC_{25} of the post cropping soil sample analyses recorded significantly lower values in treatment 33% RDF with PSB+CU than treatment 100% RDF with PSB+CU (0.171 and 0.199 dS m^{-1}respectively). However, treatments 33% RDF alone, 100% RDF alone, with PSB+Rhz and with PSB+CU were comparable with the 2nd best treatment, i.e., 33% RDF with PSB+Rhz [Table 4.15.2(a)].

In the 2nd year the treatment combination 100% RDF with PSB+Rhz registered significantly lower values of EC_{25} than treatment 100% RDF alone (0.163 and 0.214 respectively). Treatments 33% RDF alone, with PSB+CU and with PSB+Rhz, 100% RDF with PSB+CU, PSB+Rhz alone and PSB+CU alone were statistically comparable with the most effective treatment. The maximum value of 0.290 was noted in the 0 level combinations.

Table 4.15.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (blackgram) status of organic carbon (%) of soil**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.190	0.251	0.274	0.239	0.103	0.388	0.339	0.277
F_1	0.608	0.657	0.721	0.662	0.357	0.354	0.298	0.336
F_2	0.543	0.566	0.608	0.572	0.384	0.422	0.333	0.380
Mean	0.447	0.491	0.534		0.281	0.388	0.323	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.015	0.030			0.069	0.139	

In the 1st year the highest value of organic carbon in the soil analysis was in treatment 33% RDF wth PSB+CU (0.721%), which was significantly higher [Table 4.15.2(b)] than treatment 33% RDF with PSB+Rhz (0.657%), which in turn again was significantly superior to the treatments 100% RDF with PSB+CU and 33% RDF alone (0.608% in both). The minimum value of 0.190% was recorded in control.

In the 2nd year the treatment 100% RDF with PSB+Rhz combination registered significantly higher values than control plot. Treatments PSB+CU and PSB+Rhz were statistically at par.

Table 4.15.2(c) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (blackgram) status of available P_2O_5 (kg ha^{-1}) of soil**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	7.67	9.33	11.56	9.52	16.11	17.33	21.78	18.41
F_1	18.56	20.33	22.78	20.56	17.44	27.33	23.11	22.63
F_2	35.44	37.00	40.33	37.59	26.89	24.11	40.33	30.44
Mean	20.56	22.22	24.89		20.15	22.92	28.41	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.69	1.38			6.67	13.38	

In the 1st year the post-cropping soil analysis of available phosphorus revealed that the treatment 100% RDF with PSB+CU was significantly higher than treatment 100%RDF with PSB+Rhz, which in turn was markedly superior to treatment

combination 100% RDF alone (40.33, 37.00 and 35.44 kg ha^{-1} respectively). The minimum value of 7.66 kg ha^{-1} was recorded in control plot [Table 4.15.2(c)].

In the 2nd year the treatment 100% RDF with PSB+CU recorded significantly higher value than treatment 100% RDF alone (40.33 and 26.89 kg ha^{-1}). Treatment 33% RDF with PSB+Rhz was statistically comparable.

Table 4.15.2(d) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (blackgram) status of available K_2O (kg ha^{-1}) of soil**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	322.80	393.10	391.70	369.20	252.70	275.00	260.00	262.57
F_1	506.60	503.20	525.10	511.63	253.80	272.20	278.30	268.10
F_2	568.40	615.70	651.30	611.80	268.30	307.80	424.20	333.43
Mean	465.93	504.00	522.70		258.27	285.00	320.83	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		27.33	54.85			17.00	34.12	

In the 1st year the available potassium status of the soil sample in the post cropping stage was maximum [Table 4.15.2(d)] in the treatment 100% RDF with PSB+CU and was significantly higher than treatment 100% RDF alone, which was in turn superior to treatment 33% RDF alone (651.30, 568.40 and 506.60 kg ha^{-1} respectively). However, the treatment 100% RDF with PSB+Rhz (615.70 kg ha^{-1}) was at par with the most effective treatment and the treatment 33% RDF with PSB+CU (525.10 kg ha^{-1}) was statistically comparable with treatment 100% RDF alone.

In the 2nd year the treatment 100% RDF with PSB+CU registered significantly higher value than treatment 100% RDF with PSB+Rhz, which in turn was significantly superior to treatment 33% RDF with PSB+Rhz (424.20, 307.80 and 272.20 kg ha^{-1} respectively). Treatments 33% RDF with PSB+CU and PSB+Rhz alone (278.30 and 275.00 kg ha^{-1} respectively) were comparable with the 2nd most effective treatment, i.e., 100% RDF with PSB+Rhz (307.80 kg ha^{-1}).

4.4.4.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

In the 1st year the treatment FC+PM with PSB+CU recorded significantly lower values of EC_{25} than treatment FC+PM alone (0.202 and 0.239 dS m^{-1}). Treatment FC+PM with PSB+Rhz (0.219 dS m^{-1}) was statistically at par with the most effective treatment [Table 4.15.3(a)].

Table 4.15.3(a) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (blackgram) status of EC_{25} (dS m^{-1}) of soil**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.364	0.292	0.278	0.311	0.290	0.172	0.183	0.215
C_1	0.267	0.262	0.245	0.258	0.190	0.163	0.173	0.176
C_2	0.238	0.218	0.202	0.220	0.190	0.180	0.168	0.179
Mean	0.290	0.257	0.242		0.223	0.172	0.175	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.010	0.021			0.014	0.028	

In the 2nd year the treatment FC+VC with PSB+Rhz recorded significantly lower values than the control plot (0.163 and 0.290 dS m^{-1} respectvely). All treatments were statistically comparable with the most effective treatment.

The statistical analysis of the data pertaining to the percentage organic carbon status revealed that treatment FC+PM with PSB+CU registered significantly higher values than treatment FC+PM alone, which in turn was markedly superior to treatment FC+VC with PSB+CU (0.641, 0.577 and 0.537% respectively). Treatment FC+PM with PSB+Rhz was comparable with the most effective treatment [Table 4.15.3(b)].

Table 4.15.3(b) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (blackgram) status of organic carbon (%) of soil**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.306	0.364	0.426	0.365	0.103	0.388	0.339	0.277
C_1	0.459	0.494	0.537	0.497	0.357	0.354	0.298	0.336
C_2	0.577	0.614	0.641	0.611	0.384	0.422	0.333	0.380
Mean	0.447	0.491	0.534		0.281	0.388	0.323	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.015	0.030			0.069	0.139	

In the second year treatment FC+PM with PSB+Rhz registered significantly higher values than the plots with 0 level combination (0.422 and 0.103% respectively). All other treatments were at par with the most effective treatment combination.

The available phosphorus status of the soil at the post-cropping stage was significantly higher [Table 4.15.3(c)] in treatment FC+PM with PSB+CU than in treatment FC+PM with PSB+Rhz (32.56 and 28.56 kg ha^{-1} respectively). Treatment FC+PM alone registered significantly higher value than treatment FC+VC with PSB+CU, and treatment FC+VC with PSB+Rhz was comparable with the latter treatment (25.78, 23.67 and 23.00 kg ha^{-1} respectively).

Table 4.15.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (blackgram) status of available P_2O_5 (kg ha^{-1}) of soil**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	13.67	15.11	18.44	15.74	7.56	21.22	25.33	18.04
C_1	22.22	23.00	23.67	22.96	29.56	17.44	22.56	23.19
C_2	25.78	28.56	32.56	28.97	23.33	30.11	37.33	30.26
Mean	20.56	22.22	24.89		20.15	22.92	28.41	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		0.69	1.38			6.67	13.38	

In the 2nd year the treatment FC+PM with PSB+CU recorded significantly higher values than treatment FC+PM alone (37.33 and 23.33 kg ha^{-1} respectively). Treatments FC+PM with PSB+Rhz, FC+VC alone and PSB+CU alone were statistically on par with the most effective treatment.

In the 1st year the available potassium values of the post-cropping soil sample was significantly higher [Table 4.15.3(d)] in treatment FC+PM with PSB+CU than in treatment FC+PM alone, which in turn was significantly higher than treatment PSB+CU alone (620.30, 538.70 and 436.40 kg ha^{-1} respectively). Treatment FC+PM with PSB+Rhz combination (595.00 kg ha^{-1}) was on par with the most effective treatment. Further treatments FC+VC alone, with PSB+Rhz and with PSB+CU were statistically comparable with the treatment FC+PM alone.

Table 4.15.3(d) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (blackgram) status of available K_2O (kg ha^{-1}) of soil**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	333.70	405.00	436.40	391.70	208.10	289.00	275.20	257.43
C_1	525.40	512.00	511.30	516.23	288.10	280.60	253.80	274.17
C_2	538.70	595.00	620.30	584.67	278.60	285.40	433.60	332.53
Mean	465.93	504.00	522.67		258.27	285.00	320.87	
		SEd ±	CD(0.05)			SEd ±	CD(0.05)	
		27.33	54.85			17.00	34.12	

In the 2nd year also the treatment FC+PM with PSB+CU registered significantly higher value than treatment PSB+Rhz alone (433.60 and 289.00 kg ha^{-1} respectively). Treatments FC+VC alone and with PSB+Rhz alone, FC+PM alone and with PSB+Rhz and PSB+CU alone were statistically on par with the 2nd best treatment, i.e., PSB+Rhz alone.

4.5 Experiment 2: (Blackgram – Wheat – Greengram system) Crop component 2: Wheat

4.5.1 Dry matter accumulation

4.5.1.1 Fertilizer level

The data on dry matter accumulation during both the years in wheat crop of the second cropping system showed significant differences due to the varying levels of fertilizer dosage (Table 4.16). At 15 DAS in the first year, 30 DAS in both years, 45 DAS in the 2nd year, 60, 75, 90 and 105 DAS during both the years the treatment 100% RDF registered significantly higher dry weight values than treatment 33% RDF. Statistical comparability was observed in treatment 33% RDF at 75, 90 and 105 DAS in the first year. However, throughout the experimental period treatment 33% RDF recorded significantly higher values than the 0 level RDF.

4.5.1.2 Manurial forms

Significant differences due to manurial forms were observed at 30, 75 & 90 DAS in the 1st year when the FC+VC combination registered a dry weight value of 0.273 g in comparison to 0 level manure with 0.224 g at 30 DAS (Table 4.16). Treatment FC+PM (0.269 g) was statistically comparable with the best treatment.

Treatment FC+VC recorded highest values at 15 DAS in both the years and at 90 DAS in the 2nd year. Treatment FC+PM combination registered the maximum figures at 45 DAS in the 1st year, at 60 and 75 DAS in both the years, at 90 DAS in the 1st year and at 105 DAS in both the years.

4.5.1.3 Biofertilizer and/or organic spray

The biofertilizer and/or organic spray factor influenced the dry weight value of wheat in the cropping system at 30 DAS and 75 DAS in the 1st year (Table 4.16). Treatment PSB+CU produced significantly higher values than the 0 level treatment at 30 DAS in the 1st year (0.272 and 0.228 g respectively), and statistical comparability was noticed in the PSB+Azsp combination. At 75 DAS the treatment PSB+Azsp registered significantly higher values than the PSB+CU combination (9.28 and 8.35 g respectively).

Table 4.16 Effect of INM on dry weight of wheat (g/plant) during 1997-98 and 1998-99

Factors	15 DAS		30 DAS		45 DAS		60 DAS		75 DAS		90 DAS		105 DAS	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Fertilizer levels (F):														
F_0	0.066	0.151	0.200	0.236	0.979	0.459	1.898	1.321	5.764	2.454	10.71	4.809	9.183	6.616
F_1	0.110	0.151	0.254	0.394	1.099	1.229	3.447	3.593	8.705	6.831	16.21	12.37	21.31	16.02
F_2	0.129	0.127	0.311	0.593	1.019	1.941	5.056	4.907	9.600	9.580	17.34	16.00	23.19	22.89
	*	NS	*	*	NS	*	*	*	*	*	*	*	*	*
Forms of manure (C):														
C_0	0.098	0.166	0.224	0.423	1.026	1.180	3.214	3.051	6.721	5.809	13.21	10.63	16.83	13.72
C_1	0.112	0.134	0.273	0.416	1.009	1.343	3.359	3.212	8.425	6.515	15.48	12.22	17.23	15.49
C_2	0.095	0.129	0.269	0.385	1.063	1.106	3.827	3.559	9.004	6.540	15.58	10.34	19.62	16.33
	NS	NS	*	NS	NS	NS	NS	NS	*	NS	*	NS	NS	NS
Biofertilizer &/or organic spray (B):														
B_0	0.099	0.123	0.228	0.408	0.970	1.189	3.422	3.298	8.349	6.215	14.83	10.65	18.28	15.68
B_1	0.101	0.156	0.266	0.441	1.072	1.216	3.330	3.264	9.280	6.096	14.03	10.86	18.47	14.75
B_2	0.105	0.150	0.272	0.375	1.055	1.225	3.648	3.259	6.520	6.552	15.40	11.67	16.93	15.10
	NS	NS	*	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS
SEd ±	0.007	0.022	0.017	0.058	0.152	0.125	0.365	0.355	1.081	0.586	1.130	0.966	1.579	1.619
CD (0.05)	0.015	-	0.035	0.117	-	0.252	0.732	0.713	2.170	1.177	2.269	1.939	3.169	3.249
FxC FxB CxB:														
SEd ±	0.013	0.039	0.030	0.101	0.264	0.218	0.632	0.615	1.873	1.016	1.959	1.673	2.736	2.805
CD (0.05)	0.027	0.078	0.061	0.202	0.530	0.437	1.269	1.235	3.759	2.039	3.931	3.357	5.491	5.629

*Significant at P = 0.05   NS = non-significant

Table 4.16.1(a) **Effect of interaction of fertilizer levels and manurial forms on dry weight of wheat (g/plant) at 15 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.046	0.080	0.074	0.066	0.166	0.117	0.172	0.152
F_1	0.122	0.111	0.098	0.110	0.176	0.173	0.107	0.152
F_2	0.127	0.146	0.114	0.129	0.158	0.114	0.109	0.127
Mean	0.098	0.112	0.095		0.166	0.135	0.129	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.014	0.027			0.039	0.078	

The interaction of fertilizer levels and manurial forms showed some effect on the dry weight values of wheat in the cropping system [Table 4.16.1(a)]. In the 1st year at 15 DAS the treatment 100% RDF with FC+VC registered significantly higher figures than treatment 100% RDF with FC+PM, which in turn was superior to treatment FC+VC alone (0.146, 0.114 and 0.080 g respectively). Treatments 100% RDF alone and 33% RDF alone (0.127 and 0.122 g respectively) were at par with the most effective treatment. Further, treatments 33 % RDF with FC+VC and with FC+PM (0.111 and 0.098 g respectively) were comparable with treatment 100% RDF with FC+PM.

In the 2nd year however, there was no significant difference in the treatments as a result of the interaction. The maximum and minimum values were recorded respectively in treatments 33% RDF alone and with FC+PM (0.176 and 0.107 g respectively).

Table 4.16.1(b) **Effect of interaction of fertilizer levels and manurial forms on dry weight of wheat (g/plant) at 30 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.160	0.229	0.213	0.201	0.167	0.264	0.279	0.237
F_1	0.209	0.271	0.283	0.254	0.390	0.384	0.409	0.394
F_2	0.303	0.321	0.311	0.312	0.712	0.600	0.469	0.594
Mean	0.224	0.274	0.269		0.423	0.416	0.386	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.030	0.061			0.101	0.203	

At 30 DAS in the 1st year the dry weight values registered maximum in the treatment 100% RDF with FC+VC, which was significantly higher than in treatment FC+VC alone (0.321 and 0.229 g respectively). Treatments 100% RDF alone, and with FC+PM, 33% RDF with FC+PM and with FC+VC were statistically comparable with the most effective treatment [Table 4.16.1(b)].

In the 2nd year the treatment 100%RDF alone produced the highest value which was significantly higher than in treatment 100% RDF with FC+PM combination, which was in turn significantly higher than in treatment FC+PM alone (0.712, 0.469 and 0.279 g respectively). Treatment 100% RDF with FC+VC (0.600 g) was comparable to the most effective treatment. However, treatments 100% RDF with FC+PM and 33% RDF with FC+PM combination (0.469 and 0.409 g respectively) were on par with the 2nd best treatment, i.e., 100% RDF with FC+VC.

Table 4.16.1(c) **Effect of interaction of fertilizer levels and manurial forms on dry weight of wheat (g/plant) at 45 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.81	1.05	1.07	0.98	0.39	0.48	0.51	0.46
F_1	1.38	0.75	1.17	1.10	1.28	1.25	1.16	1.23
F_2	0.89	1.22	0.94	1.02	1.87	2.30	1.65	1.94
Mean	1.03	1.01	1.06		1.18	1.34	1.11	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.26	0.53			0.22	0.44	

In the 1st year at 45 DAS treatment 33% RDF alone recorded significantly higher values than control (1.376 and 0.812 g respectively) [Table 4.16.1(c)].

In the 2nd year treatment 100%RDF with FC+VC registered significantly higher figures than treatment 100% RDF with FC+PM combination, which in turn was significantly superior to treatment 33% alone (2.302, 1.650 and 1.277 g respectively). Treatment 100% RDF alone (1.87 g) was on par with the most effective treatment.

Table 4.16.1(d) **Effect of interaction of fertilizer levels and manurial forms on dry weight of wheat (g/plant) at 60 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	1.56	1.92	2.22	1.90	1.04	1.48	1.44	1.32
F_1	3.00	3.38	3.96	3.45	3.59	3.38	3.82	3.59
F_2	5.09	4.78	5.30	5.06	4.52	4.78	5.42	4.91
Mean	3.21	3.36	3.83		3.05	3.21	3.56	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.63	1.27			0.62	1.24	

At 60 DAS in the 1st year treatment 100% RDF with FC+PM recorded significantly higher value than treatment 33% RDF with FC+PM, which in turn was markedly higher than in treatment FC+PM alone (5.304, 3.963 and 2.215 g respectively) [Table 4.16.1(d)]. Treatments 100% RDF alone and with FC+VC (5.085 and 4.778 g respectively) were comparable with the most effective treatment. Further,

treatments 33% RDF alone and with FC+VC (3.381 and 2.996 g respectively) were at par with treatment 33% RDF with FC+PM.

The values recorded in the 2nd year were significantly higher in treatment 100% RDF with FC+PM than in treatment 33% RDF with FC+PM, which in turn was significantly superior to the treatment FC+VC alone (5.424, 3.815 and 1.483g respectively). Treatments 100% RDF alone and with FC+VC (4.776 and 4.522 g respectively) was comparable with the most effective treatment. Treatments 33% RDF alone and with FC+VC (3.587 and 3.376 g respectively) were on par with treatment 100% RDF alone.

Table 4.16.1(e) **Effect of interaction of fertilizer levels and manurial forms on dry weight of wheat (g/plant) at 75 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	4.30	7.86	5.13	5.76	2.04	2.55	2.78	2.45
F_1	7.84	10.12	8.39	8.79	6.10	7.23	7.16	6.83
F_2	8.02	9.03	11.76	9.60	9.29	9.77	9.68	9.58
Mean	6.72	9.00	8.43		5.81	6.51	6.54	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		1.87	3.76			1.02	2.04	

At 75 DAS in the 1st year treatment 100% RDF with FC+PM registered significantly higher value than in treatment FC+VC alone (11.76 and 7.863 g respectively). Treatments 33% RDF with FC+VC and with FC+PM and 100% RDF with FC+VC were statistically at par with the most effective treatment [Table 4.16.1(e)].

In the 2nd year the values in treatment 100% RDF with FC+VC was significantly higher than in treatment 33% RDF with FC+VC, which in turn was significantly higher than in treatment FC+PM alone (9.76, 7.23 and 2.77 g respectively). Treatments 100% RDF alone and with FC+PM (9.29 and 9.68 g respectively) were comparable with the most effective treatment. Further, treatments 33% RDF alone and with FC+PM (6.10 and 7.16 g respectively) were statistically comparable with the treatment 33% RDF with FC+VC.

At 90 DAS in the 1st year treatment 100% RDF with FC+PM registered markedly higher figures than in treatment FC+VC alone (19.16 and 15.00 g respectively). Treatments 100% RDF alone and with FC+VC, 33% RDF alone, with FC+PM and with FC+VC were statistically comparable to the most effective treatment [Table 4.16.1(f)].

Table 4.16.1(f) **Effect of interaction of fertilizer levels and manurial forms on dry weight of wheat (g/plant) at 90 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	5.69	15.00	11.46	10.72	4.11	5.97	4.35	4.81
F_1	16.61	15.89	16.11	16.20	12.96	12.15	11.99	12.37
F_2	17.32	15.56	19.16	17.35	14.81	18.53	14.66	16.00
Mean	13.21	15.48	15.58		10.63	12.22	10.33	
		SEd ± 1.96	CD (0.05) 3.93			SEd ± 1.67	CD (0.05) 3.36	

In the 2nd year the treatment 100% RDF with FC+VC recorded significantly higher values than treatment 100% RDF alone, which was in turn significantly above the treatment FC+VC alone (18.53, 14.81 and 5.96 g respectively). Howerver, treatments 100% RDF with FC+PM, 33% RDF alone, with FC+VC and with FC+PM were statistically par with the 2nd most effective treatment, i.e., 100% RDF alone.

Table 4.16.1(g) **Effect of interaction of fertilizer levels and manurial forms on dry weight of wheat (g/plant) at 105 DAS**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	6.69	10.59	10.27	9.18	5.85	7.88	6.12	6.62
F_1	21.70	21.64	20.59	21.31	13.00	16.25	18.81	16.02
F_2	22.11	19.46	27.99	23.19	22.30	22.33	24.04	22.89
Mean	16.83	17.23	19.62		13.72	15.49	16.32	
		SEd ± 2.74	CD (0.05) 5.49			SEd ± 2.81	CD (0.05) 5.63	

At 105 DAS in the 1st year treatment 100% RDF with FC+PM recorded significantly higher figures than 100% RDF alone, which in turn was markedly higher than treatment FC+VC alone (27.99, 22.11 and 10.59 g respectively). Treatments 33% RDF alone, with FC+VC and with FC+PM and 100% RDF with FC+VC were comparable with the 2nd most effective treatment, i.e., 100% RDF alone [Table 4.16.1(g)].

In the 2nd year treatment 100% RDF with FC+PM registered significantly higher values than treatment 33% RDF with FC+VC which in turn was significantly higher than treatment FC+VC (24.04, 16.25 and 7.88 g respectively). Treatments 100% RDF alone, and with FC+VC, 33% RDF with FC+PM were comparable with the most effective treatment. Treatment 33% RDF was at par with 33% RDF with FC+PM.

4.5.1.4 Interaction effect due to fertilizer and biofertilizer and/or organic spray

Table 4.16.2(a) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 15 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.061	0.067	0.071	0.066	0.130	0.228	0.097	0.151
F_1	0.112	0.107	0.112	0.110	0.120	0.110	0.226	0.152
F_2	0.124	0.130	0.132	0.129	0.120	0.131	0.130	0.127
Mean	0.099	0.101	0.105		0.123	0.156	0.151	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.014	0.027			0.039	0.078	

At 15 DAS in the 1st year the interaction of fertilizer levels and manurial forms produced significantly higher figures in treatment 100% RDF with PSB+CU than in treatment PSB+CU alone (0.132 and 0.071 g respectively). Treatments 100% RDF alone, PSB+Azsp with, 33% RDF alone, with PSB+Azsp and with PSB+CU were statistically comparable with the most effective treatment [Table 4.16.2(a)].

In the 2nd year treatment PSB+Azsp alone recorded the highest value, which was significantly higher than treatment 100% RDF with PSB+Azsp combination (0.228 and 0.131 g respectively). Treatment 33% RDF with PSB+CU (0.226 g) was comparable with the most effective treatment.

Table 4.16.2(b) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 30 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.186	0.216	0.201	0.201	0.220	0.222	0.268	0.237
F_1	0.214	0.272	0.277	0.254	0.401	0.389	0.393	0.394
F_2	0.284	0.312	0.339	0.312	0.604	0.712	0.464	0.594
Mean	0.228	0.267	0.272		0.409	0.441	0.375	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.030	0.061			0.101	0.203	

At 30 DAS in the 1st year the treatment 100% RDF with PSB+CU registered significantly higher figures than treatment 33% RDF with PSB+Azsp, which in turn was superior to treatment PSB+Azsp (0.339, 0.277 and 0.216 g respectively). Treatments 100% RDF alone and with PSB+Azsp were comparable with the most effective treatment. Treatment 33% RDF with PSB+Azsp was comparable with the 2nd best treatment, i.e., 100% RDF with PSB+Azsp [Table 4.16.2(b)].

In the 2nd year the treatment 100% RDF with PSB+Azsp recorded significantly higher values than treatment 33%RDF alone (0.712 and 0.401 g respectively). Treatment 100% RDF alone (0.604 g) was statistically at par with the most effective treatment. Further, treatment 100% RDF with PSB+CU (0.464 g) was on par with the 2nd best treatment, i.e., 100% RDF alone.

Table 4.16.2(c) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 45 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.77	1.14	1.03	0.98	0.45	0.48	0.45	0.46
F_1	1.01	1.01	1.28	1.10	1.30	1.10	1.29	1.23
F_2	1.13	1.07	0.86	1.02	1.81	2.07	1.94	1.94
Mean	0.97	1.07	1.05		1.19	1.22	1.23	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.26	0.53			0.22	0.44	

At 45 DAS in the 1st year no significant differences between the treatment was noticeable as a result of interaction of fertilizer levels and biofertilizer and/or organic spray [Table 4.16.2(c)]. The maximum and minimum values were registered in treatments 33% RDF with PSB+CU and control plot respectively (1.278 and 0.773 g respectively).

In the 2nd year however, there was significant differences due to the interaction and the treatment 100% RDF with PSB+Azsp recorded markedly higher values than treatment 33% RDF alone, which in turn was significantly higher than the treatment PSB+Azsp alone (2.07, 1.30 and 0.477 g respectively). Treatments 100% RDF alone and with PSB+CU (1.93 and 1.81 g respectively) was statistically comparable to the most effective treatment. Further, the treatments 33% RDF with PSB+CU and with PSB+Azsp were on par with the treatment 33% RDF alone.

Table 4.16.2(d) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 60 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	1.73	1.75	2.21	1.90	1.21	1.52	1.23	1.32
F_1	4.02	3.15	3.17	3.45	4.23	3.07	3.48	3.59
F_2	4.52	5.09	5.57	5.06	4.45	5.21	5.07	4.91
Mean	3.42	3.33	3.65		3.30	3.26	3.26	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.63	1.27			0.62	1.24	

At 60 DAS in the 1st year treatment 100% RDF with PSB+CU registered significantly higher figures than treatment 33% RDF alone, which was in turn superior

to treatment PSB+CU alone (5.57, 4.02 and 2.21 g respectively). Treatments 100% RDF alone and with PSB+Azsp were statistically on par with the most effective treatment combination [Table 4.16.2(d)]. Further, treatment 33% RDF with PSB+CU and with PSB+Azsp were comparable with treatment 33% RDF alone. In the 2nd year the treatment 100% RDF with PSB+Azsp registered significantly higher values than treatment 33% RDF with PSB+CU, which in turn recorded higher figures than treatment PSB+Azsp alone (5.20, 3.47 and 1.52 g respectively). Treatments 100% RDF alone and with PSB+CU and 33% RDF alone were statistically at par with the most effective treatment combination. Further, treatments 33% RDF with PSB+Azsp (3.06 g) were comparable with the treatment 33% RDF with PSB+CU.

Table 4.16.2(e) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 75 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	5.26	7.30	4.73	5.76	2.53	2.24	2.59	2.45
F_1	9.24	10.39	6.72	8.79	6.92	6.60	6.97	6.83
F_2	10.54	10.16	8.10	9.60	9.19	9.45	10.09	9.58
Mean	8.35	9.28	6.52		6.22	6.10	6.55	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		1.87	3.76			1.02	2.04	

At 75 DAS in the 1st year treatrment 100% RDF alone recorded significantly higher value than treatment 33% RDF with PSB+CU (10.54 and 6.72 g respectively). The treatments 33% RDF alone and with PSB+Azsp and 100% RDF with PSB+Azsp were statistically on par with the most effective treatment [Table 4.16.2(e)]. In the 2nd year the treatment 100% RDF with PSB+CU produced significantly higher values than treatment 33% RDF with PSB+CU, which was further significantly superior to treatment PSB+CU (10.09, 6.97 and 2.60 g respectively). The treatments 100% RDF alone and with PSB+Azsp were at par with the most effective treatment. The treatments 33% RDF alone and with PSB+Azsp were comparable with the treatment 33% RDF with PSB+CU.

Table 4.16.2(f) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 90 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	9.77	10.04	12.32	10.71	5.30	4.00	5.13	4.81
F_1	16.34	15.00	17.29	16.21	12.05	11.74	13.32	12.37
F_2	18.39	17.04	16.60	17.34	14.61	16.84	16.55	16.00
Mean	14.83	14.03	15.40		10.65	10.86	11.67	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		1.96	3.93			1.67	3.36	

The data pertaining to the dry weight values at 90 DAS in the 1st year showed that treatment 100% RDF alone registered markedly higher than treatment PSB+CU (18.39 anf 12.32 g respectively). The treatments 33% RDF alone, with PSB+CU and with PSB+Azsp, 100% RDF with PSB+CU and with PSB+Azsp were statistically on par with the most effective treatment [Table 4.16.2(f)].

In the 2nd year the treatment 100% RDF with PSB+Azsp registered significantly higher values than treatment 33% RDF with PSB+CU, which was in turn significantly above the control plot (16.84, 13.32 and 5.30 g respectively). Treatments 100% RDF alone and with PSB+CU (16.55 and 14.61 g respectively) were statistically at par with the most effective treatment. Treatments 33% RDF alone and with PSB+Azsp were comparable with the treatment 33% RDF with PSB+CU.

Table 4.16.2(g) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 105 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	9.74	9.36	8.46	9.18	6.83	7.09	5.94	6.62
F_1	24.27	23.08	16.58	21.31	15.66	14.90	17.50	16.02
F_2	20.83	22.97	25.76	23.19	24.56	22.26	21.86	22.89
Mean	18.28	18.47	16.93		15.68	14.75	15.10	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		2.74	5.49			2.81	5.63	

At 105 DAS in the 1st year the treatment 100% RDF with PSB+CU produced significantly higher dry weight figures than treatment 33% RDF with PSB+CU (25.76 and 16.58 g respectively). Treatments 33% RDF alone, with PSB+Azsp and with PSB+CU, 100% RDF alone and with PSB+CU (24.27, 23.08, 20.83 and 23.08 g respectively) were statistically comparable with the most effective treatment [Table 4.16.2(g)].

In the 2nd year treatment 100% RDF alone recorded markedly higher values than treatment 33% RDF with PSB+CU, which in turn registered superior figures than treatment PSB+Azsp alone (24.56, 17.50 and 7.08 g respectively). Treatments 100% RDF with PSB+Azsp and with PSB+CU (22.26 and 21.86 g respectively) were comparable with the most effective treatment. Treatment 33% RDF with PSB+CU (17.50 g) was on par with the 2nd best treatment combination, i.e., 100% RDF with PSB+Azsp.

4.5.1.5 Interaction effect due to manurial forms and biofertilizer and/or organic spray

Table 4.16.3(a) Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 15 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.090	0.088	0.117	0.098	0.102	0.210	0.187	0.166
C_1	0.118	0.118	0.101	0.112	0.130	0.122	0.152	0.135
C_2	0.090	0.098	0.098	0.095	0.138	0.137	0.113	0.129
Mean	0.099	0.101	0.105		0.123	0.156	0.151	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.014	0.027			0.039	0.078	

The interaction between manurial forms and biofertilizer and/or organic spray influenced the dry weight values of wheat. In the 1st year at 15 DAS the treatments FC+VC alone and with PSB+Azsp registered significantly higher values than treatment FC+PM alone (0.118 g in both and 0.090 g respectively). Treatment PSB+CU alone (0.117 g) was comparable with the most effective treatment [Table 4.16.3(a)].

In the 2nd year the treatment PSB+Azsp produced significantly higher values than treatment FC+VC alone (0.210 and 0.130 g respectively). Treatment PSB+CU alone (0.187g) was statistically comparable with the most effective treatment.

Table 4.16.3(b) Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 30 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.182	0.241	0.249	0.224	0.433	0.552	0.283	0.423
C_1	0.261	0.283	0.277	0.274	0.432	0.396	0.421	0.416
C_2	0.241	0.276	0.291	0.269	0.360	0.376	0.421	0.386
Mean	0.228	0.267	0.272		0.409	0.441	0.375	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.030	0.061			0.101	0.203	

At 30 DAS in the 1st year the treatment FC+PM with PSB+CU recorded significantly higher values than the control plot (0.291 and 0.182 g respectively). Treatments FC+VC alone, with PSB+Azsp and with PSB+CU, FC+PM with PSB+Azsp and PSB+CU alone were statistically on par with the most effective treatment [Table 4.16.3(b)].

In the 2nd year the treatment PSB+Azsp alone registered significantly higher figures than PSB+CU alone (0.552 and 0.283 g respectively).

Table 4.16.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 45 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.91	1.02	1.15	1.03	1.10	1.34	1.10	1.18
C_1	1.11	1.03	0.88	1.01	1.26	1.25	1.52	1.34
C_2	0.90	1.16	1.13	1.06	1.21	1.05	1.06	1.11
Mean	0.97	1.07	1.05		1.19	1.22	1.23	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.26	0.53			0.22	0.44	

At 45 DAS in the 1st year there was no apparent influence of the interaction of manurial forms and biofertilizer and/or organic spray on the dry weight values of wheat [Table 4.16.3(c)]. The maximum and minimum values were respectively in the treatments FC+PM with PSB+Azsp and control plot (1.16 and 0.90 g respectively).

In the 2nd year the treatment FC+VC with PSB+CU registered significantly higher values than the treatment FC+PM with PSB+Azsp (1.52 and 1.05 g respectively).

Table 4.16.3(d) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 60 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	2.73	3.24	3.66	3.21	3.41	2.82	2.92	3.05
C_1	3.61	2.84	3.63	3.36	2.95	3.24	3.44	3.21
C_2	3.93	3.90	3.65	3.83	3.54	3.73	3.41	3.56
Mean	3.42	3.33	3.65		3.30	3.26	3.26	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.63	1.27			0.62	1.24	

At 60 DAS in the 1st year no significant difference was apparent due to the interaction between factors manurial forms and biofertilizer and/or organic spray [Table 4.16.3(d)]. The maximum and minimum values were respectively in treatments FC+PM alone and control plot (3.92 and 2.73 g respectively).

In the 2nd year also significant differences were absent, and the maximum and minimum figures were recorded in treatments FC+PM with PSB+Azsp and control plot (3.73 and 2.82 g respectively).

At 75 DAS in the 1st year the treatment FC+VC with PSB+Azsp recorded markedly higher figures than treatment PSB+CU (10.52 and 6.42 g respectively). Treatments FC+PM alone and with PSB+Azsp (10.51 and 9.37 g respectively) were statistically comparable with the most effective treatment [Table 4.16.3(e)].

Table 4.16.3(e) Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 75 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	5.79	7.95	6.42	6.72	5.20	6.10	6.13	5.81
C_1	8.74	10.52	7.74	9.00	6.47	6.02	7.06	6.52
C_2	10.51	9.37	5.39	8.42	6.99	6.17	6.47	6.54
Mean	8.35	9.28	6.52		6.22	6.10	6.55	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		1.87	3.76			1.02	2.04	

In the 2nd year no significant difference was apparent due to the interaction. The maximum and minimum values were respectively registered in treatments FC+VC with PSB+CU and control plot (7.06 and 5.20 g respectively).

Table 4.16.3(f) Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 90 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	12.46	13.72	13.44	13.21	8.68	10.16	13.05	10.63
C_1	16.78	11.91	17.76	15.48	11.80	12.21	12.64	12.22
C_2	15.26	16.46	15.01	15.58	11.48	10.21	9.32	10.34
Mean	14.83	14.03	15.40		10.65	10.86	11.67	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		1.96	3.93			1.67	3.36	

At 90 DAS in the 1st year the treatment FC+VC with PSB+CU recorded significantly higher figures than treatment PSB+Azsp alone (17.76 and 13.72 g respectively). Treatments FC+VC alone and FC+PM with PSB+Azsp (16.78 and 16.46 g respectively) were statistically on par with the most effective treatment [Table 4.16.3(f)].

In the 2nd year the treatment PSB+CU produced significantly higher values of dry weight than the treatment FC+PM with PSB+CU (13.05 and 9.31 g respectively). Treatments FC+VC with PSB+CU and with PSB+Azsp (12.64 and 12.2 g respectively) were statistically comparable with the most effective treatment.

At 105 DAS in the 1st year there was apparently no difference between the treatments due to the interaction of factors manurial forms and biofertilizer and/or organic spray [Table 4.16.3(g)]. The maximum and minimum figures were registered respectively in treatments FC+PM with PSB+Azsp and PSB+CU alone (19.91 and 14.79 g respectively).

Table 4.16.3(g) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of wheat (g/plant) at 105 DAS**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	18.75	16.95	14.79	16.83	14.65	13.42	13.08	13.72
C_1	16.92	18.55	16.22	17.23	13.66	16.81	16.00	15.49
C_2	19.16	19.91	19.79	19.62	18.73	14.03	16.22	16.33
Mean	18.28	18.47	16.93		15.68	14.75	15.10	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		2.74	5.49			2.81	5.63	

In the 2[nd] year however, significant difference was observed and treatment FC+PM alone recorded markedly higher values than treatment PSB+CU alone (18.73 and 13.08 g respectively).

4.5.2 Yield and yield parameters

Table 4.17 **Effect of INM on economic and biological yield of wheat during 1997-98 and 1998-99**

Factors	Effective tiller/plant		Test weight (g)		Grain yield (kg ha^{-1})		Biological yield (kg ha^{-1})	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Fertilizer levels (F):								
F_0	2.54	3.99	28.96	30.64	1536.00	1322.00	2919.00	2536.00
F_1	7.14	8.91	31.35	33.01	3914.00	4336.00	7437.00	8118.00
F_2	8.51	11.71	35.62	31.01	5032.00	5629.00	9560.00	10490.00
	*	*	*	*	*	*	*	*
Forms of manure (C):								
C_0	5.27	7.73	31.74	31.27	2915.00	3201.00	5539.00	5958.00
C_1	6.02	8.25	31.55	31.63	3558.00	3981.00	6761.00	7165.00
C_2	6.91	8.62	32.64	31.76	4009.00	4105.00	7617.00	8017.00
	*	NS	*	NS	*	*	*	*
Biofertilizer &/or organic spray (B):								
B_0	5.92	8.05	31.77	31.61	3405.00	3561.00	6469.00	6279.00
B_1	6.60	8.39	32.27	31.56	3447.00	3807.00	6549.00	7083.00
B_2	5.68	8.17	31.90	31.48	3631.00	3920.00	6898.00	7777.00
	NS	NS	NS	NS	NS	NS	NS	*
SEd ±	0.547	0.498	0.392	0.450	164.60	157.83	312.73	475.59
CD (0.05)	1.097	1.000	0.788	0.903	330.28	316.70	627.54	954.34
FxC FxB CxB:								
SEd ±	0.947	0.863	0.680	0.779	285.10	273.40	541.70	823.70
CD (0.05)	1.901	1.732	1.365	1.564	572.19	548.71	1087.19	1653.16

*Significant at P = 0.05 NS = non-significant

4.5.2.1 Fertilizer levels

Statistical analysis of the yield attributes and yield of wheat crop in the system showed apparent influence of the varying levels of fertilizers (Table 4.17). The values of effective tiller-count during both the years (8.51 and 11.71 respectively), test weight in the 1[st] year (35.62 g), grain yield (5032.00 and 5629.00 kg ha^{-1} respectively) and biological yield (9560.00 and 10490.00 kg ha^{-1} respectively) in both years were significantly higher in treatment 100% RDF than in treatment 33% RDF which in turn was statistically superior to the 0 level combinations.

4.5.2.2 Manurial forms

The effective tiller count and test weight (6.91 numbers and 32.64 g respectively) in the 1st year, grain yield (4009.00 and 4105.00 kg ha^{-1} respectively) and biological yield (7617.00 and 8017.00 kg ha^{-1} respectively) in both the years were markedly higher in treatment FC+PM. Statistical comparability was observed in treatment FC+VC for effective tiller-count (6.02) during the 1st year and for grain yield and biological yield (3981.00 and 7165.00 kg ha^{-1} respectively) during the 2nd year (Table 4.17).

4.5.2.3 Biofertilizer and/or organic spray

The biological yield (7777.00 kg ha^{-1}) during the 2nd year was significantly higher in the treatment PSB+CU than the 0 level combination, and comparable figures (Table 4.17) were obtained by the treatment PSB+Azsp (7083.00 kg ha^{-1}).

In both the years the treatment PSB+CU showed higher values of grain yield and biological yield than treatment PSB+Azsp.

4.5.2.4 Interaction due to fertilizer levels and manurial forms

Table 4.17.1(a) Effect of interaction between fertilizer levels and manurial forms on the effective tiller count/plant of wheat

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	2.11	2.67	2.85	2.54	3.33	4.26	4.41	4.00
F_1	6.44	7.67	7.33	7.15	8.15	9.70	8.89	8.91
F_2	7.26	7.74	10.56	8.52	11.74	10.81	12.59	11.71
Mean	5.27	6.02	6.91		7.74	8.26	8.63	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.95	1.90			0.86	1.73	

In the 1st year the effective tiller count value was highly significant as a result of interaction between fertilizer levels and manurial forms [Table 4.17.1(a)]. Treatment 100% RDF with FC+PM registered markedly higher values than treatment 100% RDF with FC+VC, which in turn was significantly higher than the treatment FC+PM alone (10.56, 7.74 and 2.85 respectively). However, treatments 33% RDF alone, with FC+VC and with FC+PM and 100% RDF alone were statistically on par with the 2nd best treatment.

In the 2nd year also the treatment obtained the highest figures, which was significantly above treatment 100% RDF with FC+VC combination, which in turn was markedly higher than treatment 33% RDF with FC+PM (12.59, 10.81 and 8.88 respectively). Treatment 100% RDF alone (11.74) was comparable with the most effective treatment and treatment 100% RDF with FC+VC (10.81) was at par with the 2nd best treatment, i.e., 100% RDF alone. Further, treatment 33% RDF with FC+VC (9.69) was comparable with the treatment 100% RDF with FC+VC.

Table 4.17.1(b) Effect of interaction between fertilizer levels and manurial forms on the test weight (g) of wheat

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	28.43	29.02	29.44	28.96	29.61	31.36	30.95	30.64
F_1	31.94	30.37	31.74	31.35	33.31	32.56	33.15	33.01
F_2	34.86	35.27	36.74	35.62	30.88	30.97	31.17	31.01
Mean	31.74	31.55	32.64		31.27	31.63	31.76	
		SEd ± 0.68	CD (0.05) 1.37			SEd ± 0.78	CD (0.05) 1.56	

In the 1st year the test weight value was significantly higher in treatment 100% RDF with FC+PM than in treatment 100% RDF with FC+VC, which was in turn superior to treatment 33% RDF alone (36.74, 35.27 and 31.94 g respectively). Treatment 100% RDF (34.86 g) was on par with the 2nd best treatment, i.e., 100% RDF with FC+VC. Similarly, the treatment 33% RDF with FC+PM combination (31.74 g) was comparable with the treatment 33% RDF alone [Table 4.17.1(b)].

In the 2nd year the values in treatment 33% RDF alone were significantly higher than 100% RDF with FC+VC combination (33.31 and 30.97 g respectively). Treatments 33% RDF with FC+PM and with FC+VC and FC+VC alone were statistically comparable with the most effective treatment.

In the 1st year the grain yield of wheat was significantly higher in treatment 100% RDF with FC+PM combination than treatment 100% RDF alone, which in turn was significantly above the treatment 33% with FC+VC (5409.00, 4572.00 and 3881.00 kg ha^{-1}). Treatment 100% RDF with FC+VC (5114.00 kg ha^{-1}) was comparable with the most effective treatment. Further, treatment 33% RDF with FC+PM combination (4562.00 kg ha^{-1}) was on par with the treatment 100% RDF alone [Table 4.17.1(c)].

Table 4.17.1(c) **Effect of interaction between fertilizer levels and manurial forms on the grain yield (kg ha^{-1}) of wheat**

Factors	1997-98				1997-98			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	873.30	1680.00	2055.00	1536.10	865.10	1407.00	1694.00	1322.03
F_1	3301.00	3881.00	4562.00	3914.67	3697.00	4751.00	4561.00	4336.33
F_2	4572.00	5114.00	5409.00	5031.67	5041.00	5785.00	6060.00	5628.67
Mean	2915.43	3558.33	4008.67		3201.03	3981.00	4105.00	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		285.10	572.20			273.40	548.71	

In the 2nd year the treatment 100% RDF with FC+PM registered significantly higher values than treatment 100% RDF alone, which in turn was superior to the treatment 33% RDF alone (6060.00, 5041.00 and 3697.00 kg ha^{-1}respectively). Treatment 100% RDF with FC+VC (5785.00 kg ha^{-1}) was comparable with the most effective treatment combination. Treatments 33% RDF with FC+VC and with FC+PM (4751.00 and 4561.00 kg ha^{-1} respectively) were statistically at par with the treatment 100% RDF alone.

Table 4.17.1(d) **Effect of interaction between fertilizer levels and manurial forms on the biological yield (kg ha^{-1}) of wheat**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	1659.00	3193.00	3905.00	2919.00	1688.00	2744.00	3174.00	2535.33
F_1	6272.00	7373.00	8667.00	7437.33	6919.00	8376.00	9059.00	8118.00
F_2	8686.00	9717.00	10280.00	9561.00	9265.00	10370.00	11820.00	10485.00
Mean	5539.00	6761.00	7617.33		5957.33	7163.33	8017.67	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		541.70	1087.19			823.70	1653.17	

The biological yield figures in the 1st year was significantly higher in treatment 100% RDF with FC+PM combination than treatment 100% RDF alone, which in turn was markedly higher than treatment 33% RDF with FC+VC (10280.00, 8686.00 and 7373.00 kg ha^{-1} respectively). Treatment 100% RDF with FC+VC (9717.00 kg ha^{-1}) was comparable with the best treatment combination [Table 4.17.1(d)]. Treatment 33% RDF with FC+PM (8667.00 kg ha^{-1}) was statistically on par with the treatment 100% RDF alone. Further, the treatment 33% RDF with FC+VC was superior to 33% RDF alone (6272.00 kg ha^{-1}).

In the 2nd year also the treatment 100% RDF with FC+PM recorded markedly higher values than treatment 100% RDF alone, which was further significantly above the treatment 33% RDF alone (11820.00, 9265.00 and 6919.00 kg ha^{-1}). Treatment

100% RDF with FC+VC (10370.00 kg ha^{-1}) was on par with the most effective treatment. Treatments 100% RDF alone and 33% RDF with FC+PM (9265.00 and 9059.00 kg ha^{-1}) were statistically comparable with the 2nd most effective treatment, i.e., 100% RDF with FC+VC. Further, it was noticed that the treatment 33% RDF with FC+VC (8376.00 kg ha^{-1}) was comparable with treatment 100 RDF alone.

4.5.2.5 Interaction effect due to fertilizer levels and biofertilizer and/or organic spray

Table 4.17.2(a) Effect of interaction between fertilizer levels and biofertilizer and/or organic spray on the effective tiller count/plant of wheat

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	2.67	2.67	2.30	2.54	3.74	3.96	4.29	4.00
F_1	7.81	7.93	5.70	7.15	9.22	8.85	8.66	8.91
F_2	7.30	9.22	9.04	8.52	11.22	12.37	11.55	11.71
Mean	5.93	6.60	5.68		8.06	8.39	8.17	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.95	1.90			0.86	1.73	

In the 1st year the interaction of fertilizer levels and biofertilizer and/or organic spray produced significantly higher values of effective tiller count in treatment 100% RDF with PSB+Azsp than in treatment 100% RDF alone, which was in turn superior to the 0 level combination (9.22, 5.70 and 2.66 respectively). Treatments 100% RDF with PSB+CU, 33% RDF alone and with PSB+Azsp were comparable with the most effective treatment [Table 4.17.2(a)].

In the 2nd year the treatment 100% RDF with PSB+CU registered significantly higher values than treatment 100% RDF with PSB+Azsp, which in turn was superior to 33% RDF with PSB+CU (12.59, 10.81 and 8.88 respectively). Treatment 100% RDF (11.74) was comparable with the most effective treatment, and treatment 100% RDF with PSB+Azsp (10.81) was comparable to the 2nd best treatment. Further, treatment 33% RDF with PSB+Azsp (9.69) was at par with the treatment 100% RDF with PSB+Azsp.

In the 1st year the test weight values as a result of interaction of fertilizer levels and biofertilizer and/or organic spray were significantly higher in treatment 100% RDF with PSB+Azsp than in treatment 33.3% RDF alone, which in turn was superior to PSB+Azsp alone (36.38, 31.86 and 29.49 g respectively). Treatments 100% RDF alone and with PSB+CU (35.22 and 35.27 g respectively) were at par with the most effective

treatment. Further, the treatments 33% RDF with PSB+CU and with PSB+Azsp (31.26 and 30.94 g respectively) were comparable with the treatment 33% RDF alone [Table 4.17.2(b)].

Table 4.17.2(b) **Effect of interaction between fertilizer levels and biofertilizer and/or organic spray on the test weight (g) of wheat**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	28.23	29.49	29.17	28.96	30.35	30.72	30.85	30.64
F_1	31.86	30.94	31.26	31.35	33.35	33.12	32.54	33.00
F_2	35.22	36.38	35.27	35.62	31.13	30.85	31.03	31.00
Mean	31.77	32.27	31.90		31.61	31.56	31.47	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.68	1.37			0.78	1.56	

In the 2nd year the treatment 33% RDF alone recorded markedly higher values than treatment 100% RDF alone (33.35 and 31.13 g respectively). Treatments 33% RDF with PSB+Azsp and with PSB+CU (33.12 and 32.54 g respectively) were statistically on par with the most effective treatment.

Table 4.17.2(c) **Effect of interaction between fertilizer levels and biofertilizer and/or organic spray on the grain yield (kg ha^{-1}) of wheat**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	1366.00	1392.00	1851.00	1536.33	1063.00	1540.00	1363.00	1322.00
F_1	4006.00	3909.00	3829.00	3914.67	4270.00	4343.00	4395.00	4336.00
F_2	4843.00	5040.00	5212.00	5031.67	5348.00	5876.00	5662.00	5628.67
Mean	3405.00	3447.00	3630.67		3560.33	3919.67	3806.67	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		285.10	572.20			273.40	548.71	

In the 1st year the treatment 100% RDF with PSB+CU registered significantly higher values than treatment 33% RDF alone, which was in turn superior to the treatment PSB+CU alone (5212.00, 4006.00 and 1851.00 kg ha^{-1} respectively). Treatments 100% RDF alone and with PSB+Azsp (4843.00 and 5040.00 kg ha^{-1} respectively) were comparable with the most effective treatment. Further, the treatments 33% RDF with PSB+Azsp and with PSB+CU (3909.00 and 3829.00 kg ha^{-1} respectively) were on par with the treatment 33% RDF alone [Table 4.17.2(c)].

In the 2nd year also a similar trend was observed, and the treatment 100% RDF with PSB+Azsp registered significantly higher values than treatment 33% RDF with PSB+CU, which was in turn superior to the treatment PSB+Azsp (5876.00, 4395.00 and 1540 kg ha^{-1} respectively). The treatments 33% RDF alone and with PSB+Azsp

(4270.00 and 4343.00 kg ha^{-1} respectively) were at par with the treatment 33% RDF with PSB+CU.

Table 4.17.2(d) **Effect of interaction between fertilizer levels and biofertilizer and/or organic spray biological yield (kg ha^{-1}) of wheat**

Factors	1997-98				1997-98			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	2595.00	2645.00	3518.00	2919.33	1980.00	2969.00	2658.00	2535.67
F_1	7611.00	7427.00	7274.00	7437.33	6796.00	8349.00	9209.00	8118.00
F_2	9201.00	9576.00	9903.00	9560.00	10060.00	9932.00	11460.00	10484.00
Mean	6469.00	6549.33	6898.33		6278.67	7083.33	7775.67	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		541.70	1087.19			823.70	1653.17	

The data on the biological yield as influenced by the interaction of fertilizer levels and biofertilizer and/or organic spray revealed that the treatment 100% RDF with PSB+CU combination registered significantly higher values than the treatment 33% RDF alone, which was further superior to treatment PSB+CU alone (9903.00, 7611.00 and 3518.00 kg ha^{-1} respectively). The treatments 100% RDF alone and with PSB+Azsp (9201.00 and 9576.00 kg ha^{-1} respectively) were comparable with the most effective treatment. Further, the treatments 33% RDF with PSB+Azsp and with PSB+CU (7427.00 and 7274.00 kg ha^{-1} respectively) on par with the treatment 33% RDF alone [Table 4.17.2(d)].

In the 2nd year the treatment 100% RDF with PSB+CU recorded significantly higher values than treatment 33% RDF with PSB+Azsp, which in turn produced markedly higher values than 33% RDF alone (11460.00, 8349.00 and 6796.00 kg ha^{-1} respectively). Treatments 100% RDF alone and with PSB+Azsp (10060.00 and 9932.00 kg ha^{-1} respectively) were on par with treatment with the highest value. Further, the treatment 33% RDF with PSB+CU (9029.00 kg ha^{-1}) was comparable with the 2nd best treatment, i.e., treatment 100% RDF alone.

4.5.2.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

In the 1st year the interaction of manurial forms and biofertilzer and/or organic spray influenced the effective tiller-count, and treatment FC+PM with PSB+Azsp combination registered significantly higher values than the control plot (7.18 and 5.18 respectively). Treatments FC+PM with PSB+CU and FC+VC with PSB+Azsp combinations (6.96 and 6.92 respectively) were statistically comparable with the most effective treatment [Table 4.17.3(a)].

Table 4.17.3(a) **Effect of interaction between manurial forms and biofertilizer and/or organic spray effective tiller count/plant of wheat**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	5.18	5.70	4.93	5.27	6.44	8.18	8.59	7.74
C_1	6.00	6.92	5.15	6.02	8.77	8.52	7.48	8.26
C_2	6.59	7.19	6.96	6.91	8.96	8.48	8.44	8.63
Mean	5.93	6.60	5.68		8.06	8.39	8.17	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.95	1.90			0.86	1.73	

In the 2nd year the values in treatment FC+PM alone were significantly higher than in the control plot (8.96 and 6.44 respectively). All treatments except FC+VC with PSB+CU combination were statistically comparable with the most effective treatment.

Table 4.17.3(b) **Effect of interaction between manurial forms and biofertilizer and/or organic spray on the test weight (g) of wheat**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	30.91	32.50	31.82	31.74	30.56	31.83	31.41	31.27
C_1	31.68	32.25	30.73	31.55	31.96	30.97	31.96	31.63
C_2	32.71	32.07	33.14	32.64	32.31	31.89	31.07	31.76
Mean	31.77	32.27	31.90		31.61	31.56	31.48	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.68	1.37			0.78	1.56	

The test weight values in the 1st year was significantly higher in treatment FC+PM with PSB+CU combination than in treatment FC+VC alone (33.14 and 31.68 g respectively). The treatments FC+PM alone, PSB+Azsp alone and with FC+VC (32.71, 32.50 and 32.25 g respectively) were statistically par with the most effective treatment [Table 4.17.3(b)].

In the 2nd year the treatment FC+PM alone recorded significantly higher values above the control plot (32.31 and 30.56 g respectively).

Table 4.17.3(c) **Effect of interaction between manurial forms and biofertilizer and/or organic spray on the grain yield (kg ha^{-1}) of wheat**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	2202.00	3246.00	3298.00	2915.33	2340.00	3561.00	3703.00	3201.33
C_1	3944.00	3129.00	3603.00	3558.67	4140.00	4041.00	3762.00	3981.00
C_2	4068.00	3967.00	3991.00	4008.67	4202.00	4157.00	3955.00	4104.67
Mean	3404.67	3447.33	3630.67		3560.67	3919.67	3806.67	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		285.10	572.20			273.40	548.71	

The data on grain yield of wheat as influenced by the interaction of manurial forms and biofertilizer and/or organic spray during the 1st year showed that the maximum value was obtained by the treatment FC+PM alone (4068.00 kg ha^{-1}). Statistical comparability in the treatments FC+PM with PSB+CU and with PSB+Azsp, FC+VC alone and with PSB+CU was observed. The rest of the treatments were comparable with treatment FC+VC with PSB+CU combination [Table 4.17.3(c)].

In the 2nd year the treatment FC+PM alone registered significantly higher values than the treatment PSB+Azsp alone, which was in turn superior to the control plot (4202.00, 3561.00 and 2340.00 kg ha^{-1} respectively). All the other treatments were statistically comparable with the most effective treatment.

Table 4.17.3(d) Effect of interaction between manurial forms and biofertilizer and/or organic spray on the biological yield (kg ha^{-1}) of wheat

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	4184.00	6167.00	6266.00	5539.00	4344.00	6307.00	7221.00	5957.33
C_1	7493.00	5944.00	6845.00	6760.67	6675.00	6871.00	7948.00	7164.67
C_2	7729.00	7537.00	7584.00	7616.67	7817.00	8072.00	8160.00	8016.33
Mean	6468.67	6549.33	6898.33		6278.67	7083.33	7776.33	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		541.70	1087.19			823.70	1653.17	

In the 1st year the biological yield values were highest in treatment FC+PM alone, followed by treatments FC+PM with PSB+CU and PSB+Azsp, FC+VC alone and with PSB+CU (7729.00, 7584.00, 7537.00, 7493.00 and 6845.00 kg ha^{-1} respectively), all of which were statistically comparable with the best treatment. Further, treatments PSB+CU alone, PSB+Azsp alone and with FC+VC were on par with the treatment FC+VC with PSB+CU combination [Table 4.17.3(d)].

In the 2nd year the treatment FC+PM with PSB+CU registered significantly higher values than treatment PSB+Azsp which was in turn markedly higher than the control plot (8160.00, 6307.00 and 4344.00 kg ha^{-1} respectively). All other treatments were statistically on par with the most effective treatment.

4.5.3 Post-cropping soil status

4.5.3.1 Fertilizer levels

The analyses of soil in the post-cropping stage of wheat culture in an INM system showed marked influence on certain parameters (Table 4.18). The EC_{25} was

significantly lower in treatment 33% RDF in the 1st year and in treatment 100% RDF in the 2nd year (0.284 and 0.125 dS m^{-1} respectively). The percentage organic carbon was maximum (0.526%) in the treatment 100% RDF in the 1st year and was significantly higher than in treatment 33% RDF. The available potassium was significantly higher in treatment 100% RDF in the 1st year and in treatment 33% RDF in the 2nd year (386.90 and 406.60 kg ha^{-1} respectively) and statistical comparability was noticed in the 2nd year.

In the 2nd year significant difference was observed with regard to available phosphorus, and the maximum figures during both the years were registered in treatment 33% RDF (17.96 and 29.04 kg ha^{-1} respectively).

Table 4.18 Effect of wheat cropping under INM system on the Physico-chemical properties of the soil

Factors	pH		EC_{25} (dS m^{-1})		Organic Carbon (%)		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Fertilizer levels (F):										
F_0	7.77	7.58	0.314	0.143	0.206	0.467	14.96	23.56	334.20	344.70
F_1	7.70	7.50	0.248	0.167	0.221	0.411	17.96	29.04	352.00	406.60
F_2	7.75	7.55	0.305	0.125	0.226	0.526	12.44	24.11	386.90	377.90
	NS	NS	*	*	NS	*	NS	*	*	*
Forms of manure (C):										
C_0	7.86	7.57	0.355	0.147	0.123	0.263	10.19	13.70	261.00	264.90
C_1	7.69	7.55	0.271	0.118	0.269	0.555	20.44	27.74	385.70	456.60
C_2	7.67	7.52	0.277	0.120	0.242	0.586	14.74	35.26	426.30	407.70
	*	NS	*	*	*	*	*	*	*	*
Biofertilizer &/or organic spray (B):										
B_0	7.79	7.54	0.328	0.144	0.201	0.471	13.19	26.37	325.00	336.90
B1	7.73	7.54	0.287	0.120	0.225	0.449	14.52	24.30	379.20	379.40
B_2	7.70	7.55	0.289	0.121	0.227	0.424	17.67	26.04	368.80	413.00
	*	NS	*	*	NS	NS	NS	NS	*	*
SEd ±	0.030	0.037	0.009	0.007	0.028	0.039	4.549	2.460	17.052	24.568
CD (0.05)	0.061	-	0.019	0.015	0.058	0.080	9.123	4.930	34.217	49.299
FxC FxB CxB:										
SEd ±	0.052	0.064	0.016	0.013	0.050	0.069	7.880	4.260	29.530	42.550
CD (0.05)	0.105	0.1300	0.033	0.027	0.100	0.138	15.810	8.550	59.260	85.390

*Significant at P = 0.05 NS = non-significant

4.5.3.2 Manurial forms

The factor manurial forms significantly influenced several parameters of the soil during the course of wheat cropping (Table 4.18). The values of soil pH in the 1st year was significantly lower in treatment FC+PM than in the 0 level plots (7.67 and 7.86 respectively). The EC_{25} in both the years were markedly lower in treatment FC+VC (0.271 and 0.118 dS m^{-1} respectively).

The percentage organic carbon was significantly higher in treatment FC+VC in the 1st year and in treatment FC+PM in the 2nd year (0.269 and 0.586% respectively) than in 0 level combination.

The values of available phosphorus in the 2nd year and the available potassium in the 1st year were significantly higher in the treatment FC+PM (35.26 and 426.30 kg ha^{-1}). The available potassium in the 2nd year was markedly higher in treatment FC+VC (456.60 kg ha^{-1}). Statistical comparability was observed in all the cases except for available phosphorus in the 2nd year and available potassium in the 1st year.

4.5.3.3 Biofertilizer and/or organic spray

The soil analyses of post-wheat stage in the system showed certain influence of the INM on some of the parameters (Table 4.18). The soil pH value was significantly lower in treatment PSB+CU than in the control plot in the 1st year, and statistically par values were observed in treatment PSB+Azsp treatment (7.70, 7.79 and 7.73 respectively).

The EC_{25} figures in both the years were markedly lower in treatment PSB+Azsp (0.287 and 0.120 dS m^{-1} respectively) than in the control plot. Statistical comparability in treatment PSB+CU was observed in both the years.

The percentage organic carbon and available phosphorus in both the years did not show any significant difference. However, maximum values were generally observed in either of the treatments PSB+CU or PSB+Azsp.

The available potassium values were significantly higher in treatment PSB+Azsp in the 1st year and in treatment PSB+CU in the 2nd year (379.20 and 413.00 kg ha^{-1} respectively), and statistical comparability was noticed in either case.

4.5.3.4 Interaction effect due to fertilizer levels and manurial forms

In the 1st year the EC_{25} was significantly lower in treatment FC+PM alone than treatment 33% RDF alone, which in turn was significantly superior than treatment 100% RDF alone (0.256, 0.307 and 0.353 dS m^{-1} respectively). Treatments 33% RDF with FC+VC and with FC+PM, 100% RDF with FC+VC and with FC+PM and FC+VC alone were statistically comparable with the most effective treatment [Table 4.18.1(a)].

Table 4.18.1(a) Effect of interaction of levels of fertilizer and manurial forms on the post-cropping (wheat) EC_{25} status of soil (dS m^{-1})

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.408	0.280	0.256	0.314	0.192	0.123	0.116	0.144
F_1	0.307	0.259	0.289	0.285	0.126	0.106	0.119	0.117
F_2	0.353	0.276	0.289	0.306	0.124	0.127	0.127	0.126
Mean	0.356	0.272	0.278		0.147	0.119	0.120	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.017	0.034			0.014	0.028	

In the 2nd year the values in treatment 33% RDF with FC+VC were significantly lower than the control plot (0.106 and 0.192 dS m^{-1} respectively). All other treatments were statistically on par with the most effective treatment.

Table 4.18.1(b) Effect of interaction of levels of fertilizer and manurial forms on the post-cropping (wheat) status of organic carbon (%) in soil

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.106	0.233	0.281	0.207	0.268	0.504	0.630	0.467
F_1	0.141	0.281	0.242	0.221	0.202	0.511	0.522	0.412
F_2	0.122	0.293	0.264	0.227	0.321	0.650	0.608	0.526
Mean	0.123	0.269	0.263		0.264	0.555	0.587	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.050	0.101			0.069	0.139	

In the 1st year the percentage organic carbon values were significantly higher in treatment 100% RDF with FC+VC combination than in treatment 33% RDF alone (0.293 and 0.233% respectively). Treatments 33% RDF with FC+VC and with FC+PM combination, 100% RDF with FC+PM, FC+PM alone and FC+VC alone were statistically at par with the most effective treatment [Table 4.18.1(b)].

In the 2nd year the treatment 100% RDF with FC+VC registered significantly higher values than treatment FC+VC alone, which in turn was superior to the treatment 100% RDF alone (0.650, 0.504 and 0.321 g respectively). Treatments FC+PM alone, 100% RDF with FC+PM, 33% RDF with FC+PM and with FC+VC were statistically comparable with the most effective treatment.

The data pertaining to available phosphorus status as influenced by the interaction of fertilizer levels and manurial forms revealed that the treatment 33% RDF with FC+PM registered significantly higher values than the treatment FC+PM alone (25.33 and 8.66 kg ha^{-1} respectively). Treatment FC+VC (23.89 kg ha^{-1}) was statistically on par with the best treatment [Table 4.18.1(c)].

Table 4.18.1(c) Effect of interaction of levels of fertilizer and manurial forms on the post-cropping (wheat) available P_2O_5 (kg ha^{-1}) of soil

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	12.33	23.89	8.67	14.96	9.00	29.67	32.00	23.56
F_1	6.44	22.11	25.33	17.96	12.67	29.67	44.78	29.04
F_2	11.78	15.33	10.22	12.44	19.44	23.89	29.00	24.11
Mean	10.18	20.44	14.74		13.70	27.74	35.26	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		7.88	15.81			4.26	8.56	

The value in the 2nd year was markedly higher in treatment 33% RDF with FC+PM combination than treatment FC+PM alone, which in turn was significantly above treatment 100% RDF alone (44.78, 32.00 and 19.44 kg ha^{-1} respectively). The treatments 33% RDF with FC+VC, FC+VC alone, 100% RDF with FC+PM and with FC+VC were statistically on par with the 2nd most effective treatment, i.e., FC+PM alone.

Table 4.18.1(d) Effect of interaction of levels of fertilizer and manurial forms on the post-cropping (wheat) available K_2O (kg ha^{-1}) of soil

Factors	1997-98				1997-98			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	205.60	370.00	427.00	334.20	203.00	419.10	412.10	344.73
F_1	241.30	370.20	444.30	351.93	329.20	474.70	415.90	406.60
F_2	336.20	416.90	407.70	386.93	262.40	476.10	395.20	377.90
Mean	261.03	385.70	426.33		264.87	456.63	407.73	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		29.53	59.27			42.55	85.40	

In the 1st year the available potassium values were significantly higher in treatment 33% RDF with FC+PM than the treatment 33% RDF with FC+VC, which in turn was superior to treatment 33% RDF alone (444.30, 370.20 and 241.30 kg ha^{-1} respectively). Treatments FC+PM alone, 100% RDF with FC+PM and with FC+VC were comparable with the most effective treatment. However, treatments 33% RDF with FC+VC and FC+VC alone were on par with the 2nd best treatment, i.e., FC+PM alone [Table 4.18.1(d)].

In the 2nd year the treatment 100% RDF with FC+VC combination registered significantly higher values than treatment 33% RDF alone, which in turn was superior to the control plot (476.10, 329.20 and 203.00 kg ha^{-1}). Treatments 33% RDF with FC+VC and with FC+PM, FC+VC alone, FC+PM alone and 100% RDF with FC+PM were statistically at par with the most effective treatment. Treatment 33% RDF recorded values par with treatment FC+PM alone (329.20 and 412.10 kg ha^{-1}).

4.5.3.5 Interaction effect of fertilizer levels and biofertilizer and/or organic spray

Table 4.18.2(a) Effect of interaction of levels of fertilizer and biofertilizer and/or organic spray on the post-cropping (wheat) EC_{25} of soil (dS m^{-1})

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.391	0.281	0.271	0.314	0.178	0.124	0.129	0.144
F_1	0.287	0.274	0.293	0.285	0.122	0.110	0.118	0.117
F_2	0.308	0.306	0.304	0.306	0.134	0.126	0.118	0.126
Mean	0.329	0.287	0.290		0.145	0.120	0.122	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.017	0.034			0.014	0.028	

The EC_{25} figures in the 1st year was significantly lower in treatment PSB+Azsp alone than in the treatment 100% RDF with PSB+Azsp which in turn was markedly lower than in the control plot (0.271, 0.306 and 0.391 dS m^{-1} respectively). Treatments 33% RDF alone, with PSB+Azsp and with PS B+CU, PSB+Azsp alone and 100% RDF with PSB+CU were statistically comparable with the most effective treatment [Table 4.18.2(a)].

In the 2nd year treatment 33% RDF with PSB+Azsp registered significantly lower values than the control plot (0.110 and 0.178 dS m^{-1}). All other treatments were statistically comparable with the most effective treatment.

Table 4.18.2(b) Effect of interaction of levels of fertilizer and biofertilizer and/or organic spray on the post-cropping (wheat) soil organic carbon status (%) of soil

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.187	0.208	0.226	0.207	0.403	0.512	0.487	0.467
F_1	0.212	0.206	0.247	0.222	0.411	0.398	0.427	0.412
F_2	0.206	0.263	0.211	0.227	0.599	0.439	0.541	0.526
Mean	0.202	0.226	0.228		0.471	0.450	0.485	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.050	0.101			0.069	0.139	

The percentage organic carbon values of the post-cropping (wheat) soil apparently did not show any effect of the interaction of fertilizer levels and biofertilizer and/or organic spray [Table 4.18.2(b)]. The maximum and minimum values were registered respectively in the treatment 100% RDF with PSB+Azsp and the control plot (0.263 and 0.187% respectively).

In the 2nd year the treatment 100% RDF alone recorded markedly higher figures than the treatment 100% RDF with PSB+Azsp (0.599 and 0.439% respectively). The

treatment 100% RDF with PSB+CU (0.541%) was comparable with the most effective treatment.

Table 4.18.2(c) Effect of interaction of levels of fertilizer and biofertilizer and/or organic spray on the post-cropping (wheat) available P_2O_5 of soil (kg ha^{-1})

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	16.11	17.00	11.78	14.96	23.44	22.89	24.33	23.55
F_1	8.11	13.56	32.22	17.96	31.78	29.44	25.89	29.04
F_2	15.33	13.00	9.00	12.44	23.89	20.56	27.89	24.11
Mean	13.18	14.52	17.67		26.37	24.30	26.04	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		7.88	15.81			4.26	8.56	

The available phosphorus status was significantly higher in treatment 33% RDF with PSB+CU combination than treatment PSB+Azsp alone (32.22 and 17.00 kg ha^{-1}).

In the 2nd year the available phosphorus was significantly higher in treatment 33% RDF alone than in treatment PSB+Azsp alone (31.78 and 22.89 kg ha^{-1} respectively). Treatment 33% RDF with PSB+Azsp (29.44 kg ha^{-1}) was on par with the most effective treatment [Table 4.18.2(c)].

Table 4.18.2(d) Effect of interaction of levels of fertilizer and biofertilizer and/or organic spray on the post-cropping (wheat) available K_2O (kg ha^{-1})

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	305.70	369.00	327.90	334.20	316.00	310.20	408.00	344.73
F_1	350.40	356.40	349.00	351.93	336.30	421.30	462.10	406.57
F_2	319.00	412.20	429.60	386.93	358.20	406.80	368.80	377.93
Mean	325.03	379.20	368.83		336.83	379.43	412.97	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		29.53	59.27			42.55	85.40	

The available potassium status of the post-cropping (wheat) soil samples showed significantly higher values in treatment 100% RDF with PSB+CU than in treatment PSB+Azsp alone, which in turn was superior to treatment 33% RDF alone (429.60 and 369.00 and 350.40 kg ha^{-1} respectively). Treatment 100% RDF with PSB+Azsp (412.00 kg ha^{-1}) was comparable with the most effective treatment. Further, it was noticed that the treatment PSB+Azsp alone was statistically on par with the 2nd most effective treatment, i.e., 100% RDF with PSB+Azsp combination [Table 4.18.2(d)].

In the 2nd year the treatment 33% RDF with PSB+CU registered significantly higher values than treatment 100% RDF with PSB+CU (462.10 and 368.80 kg ha^{-1}).

Treatments 33% RDF with PSB+Azsp, PSB+CU alone and 100% RDF with PSB+Azsp were statistically comparable with the most effective treatment.

4.5.3.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

Table 4.18.3(a) Effect of interaction of manurial forms and biofertilizer and/or organic spray on the post-cropping (wheat) EC_{25} (dSm^{-1}) of soil

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.436	0.318	0.314	0.356	0.170	0.134	0.138	0.147
C_1	0.281	0.262	0.271	0.271	0.132	0.112	0.111	0.119
C_2	0.269	0.281	0.283	0.278	0.132	0.113	0.116	0.120
Mean	0.329	0.287	0.290		0.145	0.120	0.122	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.017	0.034			0.014	0.028	

In the 1st year the interaction of manurial forms and biofertilizer and/or organic spray showed marked influence on the values of EC_{25} [Table 4.18.3(a)]. The treatment combination FC+VC with PSB+Azsp registered significantly lower figures than the treatment PSB+CU alone, which in turn was significantly higher than the treatment PSB+Azsp alone (0.262, 0.314 and 0.318 dS m^{-1} respectively).

In the 2nd year the treatment combination FC+VC with PSB+CU registered significantly lower values (0.111 and 0.170 dS m^{-1} respectively) than the control plot. All treatments were statistically at par with the most effective treatment.

Table 4.18.3(b) Effect of interaction of manurial forms and biofertilizer and/or organic spray on the post-cropping (wheat) soil organic carbon (%) status

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.099	0.123	0.147	0.123	0.302	0.238	0.251	0.264
C_1	0.272	0.248	0.288	0.269	0.503	0.572	0.590	0.555
C_2	0.233	0.306	0.249	0.263	0.608	0.539	0.613	0.587
Mean	0.201	0.226	0.228		0.471	0.450	0.485	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.050	0.101			0.069	0.139	

Post harvest analysis of soil organic carbon in the 1st year revealed that that the treatment FC+PM with PSB+Azsp recorded significantly higher values than treatment PSB+CU alone (0.306 and 0.147% respectively). Treatments FC+VC alone, with PSB+Azsp and with PSB+CU, FC+PM alone and with PSB+CU were comparable with the treatment FC+PM with PSB+Azsp [Table 4.18.3(b)].

In the 2nd year the treatment combination FC+PM with PSB+CU registered markedly higher figures than control plot (0.613 and 0.302% respectively). Treatments FC+PM alone and with PSB+Azsp, FC+VC alone, with PSB+CU and with PSB+Azsp were statistically at par with the treatment figuring maximum values.

Table 4.18.3(c) Effect of interaction of manurial forms and biofertilizer and/or organic spray on the post-cropping (wheat) available P_2O_5 (kg ha^{-1}) in soil

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	8.67	9.33	12.56	10.19	12.67	14.22	14.22	13.70
C_1	21.33	24.67	15.33	20.44	29.89	24.56	28.78	27.74
C_2	9.56	9.56	25.11	14.74	36.56	34.11	35.11	35.26
Mean	13.18	14.52	17.67		26.37	24.30	26.04	
		SEd ± 7.88	CD (0.05) 15.81			SEd ± 4.26	CD (0.05) 8.56	

The available phosphorus status of the soil as influenced by interaction [Table 4.18.3(c)] of manurial forms and biofertilizer and/or organic spray revealed that the treatment combination FC+PM with PSB+CU recorded the maximum value followed by treatment FC+VC with PSB+Azsp, both of which were comparable and significantly superior to the control plot (25.11 and 24.67 kg ha^{-1}).

In the 2nd year the treatment FC+PM alone recorded markedly higher figures than treatment FC+VC with PSB+Azsp, which in turn was superior to treatment PSB+CU alone (36.56, 24.56 and 14.22 kg ha^{-1} respectively). Treatments FC+PM with PSB+CU and with PSB+Azsp, FC+VC alone and with PSB+CU alone were statistically on par with the most effective treatment. Further, the treatment FC+VC with PSB+Azsp (24.56 kg ha^{-1}) was comparable with treatment FC+VC alone.

Table 4.18.3(d) Effect of interaction of manurial forms and biofertilizer and/or organic spray on the post-cropping (wheat) available K_2O (kg ha^{-1}) in soil

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	184.70	314.20	284.20	261.03	200.20	286.20	308.20	264.87
C_1	361.90	393.10	402.10	385.70	404.60	455.40	509.90	456.63
C_2	428.60	430.30	420.10	426.33	405.80	396.70	420.80	407.77
Mean	325.07	379.20	368.80		336.87	379.43	412.97	
		SEd ± 29.53	CD (0.05) 59.27			SEd ± 42.55	CD (0.05) 85.40	

In the 1st year available potassium in the soil was significantly higher in treatment FC+PM with PSB+Azsp than in treatment FC+VC alone, which was in turn higher than control plot (430.30, 361.90 and 184.70 kg ha^{-1} respectively). Treatments

FC+PM alone and with PSB+CU, FC+VC with PSB+CU and with PSB+Azsp were statistically comparable. The treatment FC+VC alone (361.90 kg ha^{-1}) was comparable with the treatment FC+PM with PSB+CU [Table 4.18.3(d)].

In the 2nd year the treatment FC+VC with PSB+CU registered markedly higher values than the treatment FC+PM with PSB+CU, which in turn was superior to treatment PSB+CU alone (509.90, 420.80 and 308.20 kg ha^{-1} respectively). The treatment FC+VC with PSB+Azsp (455.40 kg ha^{-1}) was on par with the most effective treatment. Further the treatments FC+PM alone, with PSB+CU and with PSB+Azsp and FC+VC alone were comparable with the 2nd most effective treatment, i.e., FC+VC with PSB+Azsp.

4.6 Experiment 2: (Blackgram – Wheat – Greengram system)
Crop component: 3 Greengram

4.6.1 Dry matter accumulation

Table 4.19 Effect of INM on dry weight of greengram (g/plant) during 1997-98 and 1998-99

Factors	15 DAS		30 DAS		45 DAS	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Fertilizer levels (F):						
F_0	0.624	0.220	3.917	2.364	10.81	11.48
F_1	0.812	0.277	4.882	3.563	13.98	14.40
F_2	0.907	0.321	5.132	3.972	13.63	16.58
	*	*	*	*	*	*
Forms of manure (C):						
C_0	0.750	0.238	3.777	2.744	11.65	11.79
C_1	0.784	0.298	5.073	3.579	13.69	15.63
C_2	0.809	0.282	5.081	3.376	13.16	15.03
	NS	*	*	*	*	*
Biofertilizer &/or organic spray (B):						
B_0	0.738	0.267	4.323	3.231	12.52	13.47
B_1	0.844	0.288	4.490	3.252	12.65	14.57
B_2	0.761	0.263	5.117	3.461	13.25	14.42
	NS	NS	*	NS	NS	NS
SEd ±	0.0466	0.0212	0.3492	0.2367	0.8120	1.1256
CD (0.05)	0.0936	0.0426	0.7007	0.4749	1.6290	2.2587
FxC FxB CxB:						
SEd ±	0.0808	0.0368	0.6049	0.4100	1.4060	1.9500
CD (0.05)	0.1620	0.0730	1.2140	0.8228	2.8120	3.1300

*Significant at P = 0.05 NS = non-significant

4.6.1.1 Fertilizer levels

The fertilizer levels in the INM package administered for greengram in the cropping system influenced the dry matter accumulation at all stages in both the years (Table 4.19). The treatment 100% RDF level registered significantly higher plant dry weight values at 15 DAS (0.907 and 0.321 g respectively) and 30 DAS (5.13 and 3.97 g respectively) in both the years and at 45 DAS (16.58 g) in the 2nd year. The treatment 33% RDF level recorded markedly higher values at 45 DAS (13.98 g) in the 1st year. Statistical comparability between the two levels was observed at all stages except at 15 DAS.

4.6.1.2 Manurial forms

The dry matter accumulation pattern in greengram component of the cropping system was markedly influenced by the varying manurial forms (Table 4.19). At 15 & 30 DAS in the 2nd year and at 45 DAS in both the years the treatment FC+VC recorded significantly higher figures (0.298, 3.579, 13.61 and 15.63 g respectively). At 30 DAS in the 1st year the treatment FC+PM produced the maximum value (5.081 g), which was

significantly higher than the 0 level combination. In both the years at these stages statistical comparability was noticed.

4.6.1.3 Biofertilizer and/or organic spray

The dry weight values apparently showed no significant difference due to the treatment biofertilizer and/or organic spray except at 30 DAS in the 1st year (Table 4.19). However, the higher values were registered in either of the treatments PSB+CU or PSB+Rhz.

4.6.1.4 Interaction effect due to fertilizer levels and manurial forms

Table 4.19.1(a) Effect of interaction of fertilizer levels and manurial forms on dry weight of greengram (g/plant) at 15 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.509	0.631	0.732	0.624	0.172	0.250	0.239	0.220
F_1	0.818	0.820	0.800	0.813	0.257	0.296	0.280	0.277
F_2	0.926	0.901	0.897	0.908	0.286	0.350	0.329	0.322
Mean	0.751	0.784	0.810		0.238	0.299	0.283	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.081	0.162			0.037	0.074	

The interaction of fertilizer levels and manurial forms showed marked influence on the dry weight at 15 DAS in the 1st year [Table 4.19.1(a)]. The treatment 100% RDF alone registered significantly higher values over the treatment FC+PM alone, which in turn was higher than the control (0.926, 0.732 and 0.509 g respectively). Treatments 100% RDF with FC+VC and with FC+PM, 33% RDF alone, with FC+VC and with FC+PM were statistically at par with the most effective treatment.

In the 2nd year the treatment 100% RDF with FC+VC registered significantly higher figures than treatment 33% RDF alone, which in turn was superior to control (0.350, 0.257 and 0.172 g respectively). The treatments 100% RDF alone and with FC+PM, 33% RDF with FC+VC and with FC+PM were comparable with the treatment with the maximum values. Treatment FC+VC alone (0.250 g) was on par with the treatment 33% RDF combinations and the 100% RDF alone.

In the 1st year at 30 DAS the treatment 100% RDF with FC+VC produced markedly higher figures than 100% RDF alone [Table 4.19.1(b)], which in turn was higher than in control (5.68, 4.39 and 2.68 g respectively). The treatment 33% RDF with FC+VC (5.41 g) was statistically on par with the most effective treatment. Further, the treatment

FC+VC alone was comparable with the treatment combination 100% RDF with FC+PM (4.12 and 5.32 g respectively).

Table 4.19.1(b) Effect of interaction of fertilizer levels and manurial forms on dry weight of greengram (g/plant) at 30 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	2.69	4.12	4.95	3.92	2.15	2.52	2.42	2.36
F_1	4.26	5.41	4.98	4.88	2.80	3.88	4.01	3.56
F_2	4.39	5.69	5.32	5.13	3.28	4.33	4.31	3.97
Mean	3.78	5.07	5.08		2.74	3.58	3.58	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.60	1.21			0.41	0.82	

In the 2nd year the treatment 100% RDF with FC+VC obtained significantly higher values of dry weight than the treatment 100% RDF alone, which in turn was significantly above the treatment 33% RDF alone (4.33, 3.28 and 2.80 g respectively). The treatments 100% RDF with FC+PM, 33% RDF with FC+PM and with FC+VC were at par with the most effective treatment. Further, treatment 100% RDF alone was comparable with the treatment 33% RDF with FC+PM (4.00 g).

Table 4.19.1(c) Effect of interaction of fertilizer levels and manurial forms on dry weight of greengram (g/plant) at 45 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	9.87	11.73	10.82	10.81	8.55	13.76	12.12	11.48
F_1	12.26	15.55	14.13	13.98	12.06	14.72	16.42	14.40
F_2	12.81	13.57	14.52	13.63	14.77	18.41	16.56	16.58
Mean	11.65	13.62	13.16		11.79	15.63	15.03	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		1.41	2.82			1.95	3.91	

At 45 DAS in the 1st year the treatment 33% RDF with FC+VC registered significantly higher values than treatment 33% RDF alone (15.55 and 12.26 g respectively). The treatments 100% RDF with FC+PM and 33% RDF with FC+PM (14.52 and 14.13 g respectively) showed parity with the most effective treatment [Table 4.19.1(c)].

In the 2nd year the maximum value was produced by the treatment 100% RDF with FC+VC followed by 100% RDF with FC+PM, 33% RDF with FC+PM and 100% RDF alone, all of which were comparable with each other and significantly above treatment FC+PM alone.

4.6.1.5 Interaction due to fertilizer levels and biofertilizer and/or organic spray

Table 4.19.2(a) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of greengram (g/plant) at 15 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.558	0.668	0.647	0.624	0.191	0.250	0.220	0.220
F_1	0.771	0.871	0.796	0.813	0.273	0.266	0.293	0.277
F_2	0.888	0.993	0.842	0.908	0.338	0.350	0.277	0.322
Mean	0.739	0.844	0.762		0.267	0.289	0.263	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.081	0.162			0.037	0.074	

At 15 DAS in the 1st year the treatments showed significant variation as a result of the interaction between fertilizer levels and biofertilizer and/or organic spray [Table 4.19.2(a)]. Treatment 100% RDF with PSB+Rhz recorded markedly higher figures than the treatment 33% RDF with PSB+CU (0.993 and 0.796 g respectively). Treatments 100% RDF alone and with PSB+CU and 33% RDF with PSB+Rhz were statistically on par with the best treatment.

In the 2nd year the highest values were registered in treatment 100% RDF with PSB+Rhz combination followed by 100% RDF alone, 33% RDF with PSB+CU and 100% RDF with PSB+CU combinations (0.350, 0.338, 0.293 and 0.277 g respectively), all of which were at par. The minimum figure of 0.191 g was noted in the 0 level combinations.

Table 4.19.2(b) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of greengram (g/plant) at 30 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	3.17	4.42	4.16	3.92	1.98	2.34	2.78	2.36
F_1	4.94	4.31	5.39	4.88	3.41	3.68	3.60	3.56
F_2	4.86	4.74	5.80	5.13	4.31	3.74	3.87	3.97
Mean	4.32	4.49	5.12		3.23	3.25	3.42	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.60	1.21			0.41	0.82	

In the 1st year at 30 DAS the interaction between fertilizer levels and biofertilizer and/or organic spray produced significantly higher values in treatment 100% RDF with PSB+CU than in PSB+Rhz alone (5.80 and 4.42 g respectively). The treatment 33% RDF with PSB+CU (5.39 g) was statistically comparable with the most effective treatment combination [Table 4.19.2(b)].

In the 2^{nd} year the treatment 100% RDF alone recorded significantly higher figures than the treatment 33% RDF alone, which in turn was markedly above the treatment PSB+Rhz alone (4.30, 3.40 and 2.33 g respectively). The treatments 100% RDF with PSB+CU and with PSB+Rhz, 33% RDF with PSB+Rhz and with PSB+CU were comparable with the most effective treatment.

Table 4.19.2(c) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on dry weight of greengram (g/plant) at 45 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	9.16	11.21	12.05	10.81	9.48	12.16	12.79	11.48
F_1	15.24	12.97	13.72	13.98	14.18	14.71	14.31	14.40
F_2	13.15	13.78	13.97	13.63	16.76	16.84	16.14	16.58
Mean	12.52	12.65	13.25		13.47	14.57	14.41	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		1.41	2.82			1.95	3.91	

At 45 DAS in the 1^{st} year the treatment 33% RDF alone recorded significantly higher figures than the treatment PSB+CU alone, which in turn was superior to the control (15.24, 12.05 and 9.16 g respectively). All other treatments except PSB+Rhz alone and PSB+CU alone were comparable with the treatment with the maximum values [Table 4.19.2(c)].

In the 2^{nd} year the highest value was produced by the treatment combination 100% RDF with PSB+Rhz which was significantly above treatment PSB+CU alone (16.84 and 12.79 g respectively). The treatments 100% RDF alone and with PSB+CU (16.76 and 16.14 g respectively) were statistically at par with the most effective treatment. Further, the treatments with 33% RDF combinations were comparable with the treatment 100% RDF with PSB+CU combination.

4.6.1.6 Interaction due to manurial forms and biofertilizer and/or organic spray

The interaction between manurial forms and biofertilizer and/or organic spray influenced the dry matter accumulation, and the treatment FC+PM with PSB+Rhz registered markedly highest value (0.90 g) in the 1^{st} year at 15 DAS [Table 4.19.3(a)]. The treatments PSB+Rhz alone and FC+VC with PSB+CU (0.870 and 0.847 g respectively) were on par with the most effective treatment.

In the 2^{nd} year the treatment FC+VC with PSB+Rhz registered markedly higher figures than the treatment PSB+CU alone (0.317 and 0.231 g respectively).

Treatment FC+VC (0.308 g) alone was comparable with the treatment with the maximum value.

Table 4.19.3(a) Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of greengram (g/plant) at 15 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.672	0.870	0.710	0.751	0.207	0.277	0.231	0.238
C_1	0.743	0.762	0.847	0.784	0.308	0.317	0.271	0.299
C_2	0.801	0.900	0.728	0.810	0.288	0.272	0.288	0.283
Mean	0.739	0.844	0.762		0.267	0.289	0.263	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.081	0.162			0.037	0.074	

Table 4.19.3(b) Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of greengram (g/plant) at 30 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	3.53	3.36	4.44	3.78	2.57	2.79	2.88	2.74
C_1	4.61	4.89	5.72	5.07	3.65	3.37	3.72	3.58
C_2	4.83	5.22	5.19	5.08	3.48	3.60	3.65	3.58
Mean	4.32	4.49	5.12		3.23	3.25	3.42	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.60	1.21			0.41	0.82	

At 30 DAS in the 1st year the treatment FC+VC with PSB+CU recorded significantly higher values than the treatment PSB+CU alone (5.71 and 4.44 g respectively). Treatments FC+PM alone, with PSB+Rhz and with PSB+CU and FC+VC with PSB+Rhz were statistically at par with the most effective treatment [Table 4.19.3(b)].

In the 2nd year the treatment FC+VC with PSB+CU combination produced the maximum value followed by treatments FC+VC alone and FC+PM with PSB+CU, all of which were comparable and significantly above treatment PSB+Rhz alone.

Table 4.19.3(c) Effect of interaction of manurial forms and biofertilizer and/or organic spray on dry weight of greengram (g/plant) at 45 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	10.44	11.92	12.58	11.65	9.93	11.98	13.46	11.79
C_1	13.27	13.38	14.19	13.61	15.70	16.30	14.89	15.63
C_2	13.84	12.67	12.96	13.16	14.78	15.43	14.89	15.03
Mean	12.52	12.66	13.24		13.47	14.57	14.41	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		1.41	2.82			1.95	3.91	

At 45 DAS in the 1[st] year the treatment FC+VC with PSB+CU combination registered significantly higher figures than control (14.19 and 10.44 g respectively). Treatments FC+PM alone, FC+VC alone and with PSB+Rhz were statistically on par with the most effective tr eatment [Table 4.19.3(c)].

In the 2[nd] year the treatment FC+VC with PSB+Rhz recorded markedly higher figures than PSB+CU alone (16.30 and 13.46 g respectively). All treatments except PSB+Rhz and PSB+CU were statistically comparable with the treatment with the highest values.

4.6.2 Nodulation pattern

4.6.2.1 Fertilizer levels

The data pertaining to the nodule count of greengram crop in the system showed significant effect due to the varying levels of fertilizer only at the early stages during both the years (Table 4.20). The 0 level RDF combination recorded significantly higher number of nodules at 15 DAS (21.69 and 16.82 respectively). However, the treatment 33% RDF during both the years registered statistically par values (19.58 and 14.79 respectively). The same trend continued throughout the crop period except in the 2[nd] year at 45 DAS, when the maximum figures (43.90) were produced in treatment 33% RDF.

Table 4.20 Effect of INM on nodule count of greengram (number/plant) during 1997-98 and 1998-99

Factors	15 DAS		30 DAS		45 DAS	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Fertilizer levels (F):						
F_0	21.69	16.82	51.69	43.86	39.16	34.97
F_1	19.58	14.79	42.92	42.53	36.92	43.90
F_2	14.91	10.29	40.93	33.87	36.00	39.08
	*	*	NS	NS	NS	NS
Forms of manure (C):						
C_0	17.84	14.60	42.47	40.05	36.79	36.74
C_1	20.60	13.44	49.48	39.52	41.48	38.98
C_2	17.74	13.86	43.60	40.70	33.81	42.23
	NS	NS	NS	NS	NS	NS
Biofertilizer &/or organic spray (B):						
B_0	18.79	14.70	43.73	40.00	36.23	36.97
B_1	20.28	14.24	48.91	39.81	37.90	36.96
B_2	17.11	12.96	42.91	40.45	37.95	44.02
	NS	NS	NS	NS	NS	NS
SEd ±	1.702	1.426	5.728	4.927	4.136	4.338
CD (0.05)	3.410	2.862	-	-	-	-
FxC FxB CxB:						
SEd ±	2.949	2.471	9.922	8.535	7.165	7.515
CD (0.05)	5.918	4.959	19.913	17.129	14.380	15.082

* Significant at P = 0.05 NS = non-significant

4.6.2.2 Manurial forms

The manurial forms did not show any perceivable influence on the nodulation pattern during the cropping period in both the years (Table 4.20) . However, the maximum figures at successive stages were registered in either of the treatments FC+PM or FC+VC, except at 15 DAS in the 2nd year.

4.6.2.3 Biofertilizer and/or organic spray

The biofertilizer and/or organic spray factor in the INM package administered to the greengram crop in the system did not significantly effect the nodule count (Table 4.20). However, the highest nodule count values per plant at successive stages were noted in either the treatment PSB+Rhz or PSB+CU, except at 15 DAS in the 2nd year.

4.6.2.4 Interaction due to fertilizer levels and manurial forms

At 15 DAS in the 1st year the treatment FC+VC recorded the highest value of nodule count, which was significantly higher than the treatment 33% RDF alone (24.74 and 18.70 respectively). The 0 level combination (20.44) was comparable with the most effective treatment [Table 4.20.1(a)].

Table 4.20.1(a) Effect of interaction of fertilizer levels and manurial forms on nodule count of greengram (number/plant) at 15 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	20.44	24.74	19.89	21.69	17.74	15.14	17.59	16.82
F_1	18.70	20.03	20.00	19.58	14.96	15.77	13.63	14.79
F_2	14.37	17.03	13.33	14.91	11.11	9.40	10.37	10.29
Mean	17.84	20.60	17.74		14.60	13.44	13.86	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		2.95	5.92			2.47	4.96	

In the 2nd year the maximum count was noted in the 0 level combination, which was significantly higher than in the treatment 100% RDF alone (17.74 and 11.11 respectively). The treatments FC+PM alone, 33% RDF with FC+VC and FC+VC alone were statistically at par with the combination with maximum values.

At 30 DAS in the 1st year the treatment 33% RDF with FC+VC combination produced the highest values (53.81). Treatment FC+VC and the 0 level combinations were on par with the treatment with the maximum values [Table 4.20.1(b)].

Table 4.20.1(b) Effect of interaction of fertilizer levels and manurial forms on nodule count of greengram (number/plant) at 30 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	52.89	52.96	49.22	51.69	37.81	39.92	53.85	43.86
F_1	31.78	53.81	43.18	42.92	43.33	43.07	41.18	42.53
F_2	42.74	41.66	38.40	40.93	39.00	35.55	27.07	33.87
Mean	42.47	49.48	43.60		40.05	39.51	40.70	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		9.92	19.91			8.54	17.13	

In the 2nd year the treatment FC+PM alone registered significantly higher number than treatment 100% RDF with FC+VC (53.85 and 35.55 respectively).

At 45 DAS in the 1st year the treatment FC+VC produced [Table 4.20.1(c)] significantly higher number than the treatment 100% RDF with FC+VC (45.07 and 29.40 respectively).

Table 4.20.1(c) Effect of interaction of fertilizer levels and manurial forms on nodule count of greengram (number/plant) at 45 DAS

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	37.74	45.07	34.66	39.16	30.22	39.96	34.74	34.97
F_1	34.66	38.74	37.37	36.92	40.63	42.07	49.00	43.90
F_2	37.96	40.63	29.40	36.00	39.37	34.92	42.96	39.08
Mean	36.79	41.48	33.81		36.74	38.98	42.23	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		7.17	14.38			7.52	15.08	

In the 2nd year the maximum count was recorded in treatment combination 33% RDF with FC+PM, which was significantly higher than control (49.00 and 30.22 respectively).

4.6.2.5 Interaction effect due to fertilizer levels and biofertilizer and/or organic spray

Table 4.20.2(a) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on nodule count of greengram (number/plant) at 15 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	20.70	23.89	20.48	21.69	16.59	15.85	18.03	16.82
F_1	18.26	21.44	19.04	19.58	17.29	16.44	10.63	14.79
F_2	17.41	15.52	11.81	14.91	10.22	10.44	10.22	10.29
Mean	18.79	20.28	17.11		14.70	14.24	12.96	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		2.95	5.92			2.47	4.96	

The nodule count figures at 15 DAS in the 1st year were highest in treatment PSB+Rhz alone and was significantly higher than in treatment 100% RDF alone (23.89 and 17.41 respectively). The values with statistical parity were not observed in any of the treatment combinations [Table 4.20.2(a)].

In the 2nd year the figures in treatment PSB+CU was significantly higher than in treatment 33% RDF with FC+PM (18.03 and 10.63 respectively). Treatments 33% RDF alone and with PSB+Rhz, PSB+Rhz alone were comparable with the most effective treatment.

Table 4.20.2(b) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on nodule count of greengram (number/plant) at 30 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F0	50.63	54.15	50.29	51.69	43.30	44.15	44.14	43.86
F1	48.07	44.18	36.51	42.92	34.66	45.22	47.70	42.53
F2	32.48	48.40	41.92	40.93	42.03	30.07	29.52	33.87
Mean	43.73	48.91	42.91		40.00	39.81	40.45	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		9.92	19.91			8.54	17.13	

At 30 DAS in the 1st year the treatment PSB+Rhz alone recorded significantly higher nodule count values [Table 4.20.2(b)] than the treatment 100% RDF alone (54.15 and 32.48 respectively).

In the 2nd year the treatment combination 33% RDF with PSB+CU registered markedly higher figures than the treatment 100% RDF with PSB+CU (47.70 and 29.52 respectively).

Table 4.20.2(c) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on nodule count of greengram (number/plant) at 45 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	35.85	45.26	36.37	39.16	27.22	36.00	41.70	34.97
F_1	41.52	30.55	38.70	36.92	45.77	35.03	50.89	43.90
F_2	31.33	37.89	38.78	36.00	37.92	39.85	39.48	39.08
Mean	36.23	37.90	37.95		36.97	36.96	44.02	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		7.17	14.38			7.52	15.08	

At 45 DAS in the 1st year the nodule count [Table 4.20.2(c)] was maximum in treatment PSB+Rhz which was significantly over the treatment 33% RDF with PSB+Rhz (45.26 and 30.55 respectively).

In the 2nd year the treatment 33% RDF with PSB+CU recorded the maximum nodule count and treatment 33% RDF alone was comparable (50.89 and 45.77 respectively). The minimum figure was recorded in the 0 level combination (27.22).

4.6.2.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

Table 4.20.3(a) Effect of interaction of manurial forms and biofertilizer and/or organic spray on nodule count of greengram (number/plant) at 15 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	20.40	19.29	13.81	17.83	15.92	13.59	14.29	14.60
C_1	18.81	21.00	22.00	20.60	13.40	13.70	13.22	13.44
C_2	17.15	20.55	15.52	17.74	14.78	15.44	11.37	13.86
Mean	18.79	20.28	17.11		14.70	14.24	12.96	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		2.95	5.92			2.47	4.96	

At 15 DAS in the 1st year the interaction of manurial forms and biofertilizer and/or organic spray influenced the nodule count [Table 4.20.3(a)]. The treatment FC+VC with PSB+CU recorded significantly higher values than the treatment PSB+CU (22.00 and 13.81 respectively). Statistical parity was observed in treatments FC+VC with PSB+Rhz and FC+PM with PSB+Rhz combinations (21.00 and 20.55 respectively).

However, in the 2nd year significant influence on the nodulation pattern due to the interaction was absent. The maximum and minimum values were noticed respectively in the 0 level combination and FC+PM with PSB+CU combination (15.92 and 11.37 respectively).

Table 4.20.3(b) Effect of interaction of manurial forms and biofertilizer and/or organic spray on nodule count of greengram (number/plant) at 30 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	46.63	40.52	40.26	42.47	31.89	48.29	39.96	40.05
C_1	43.81	57.96	46.66	49.48	41.66	42.00	34.88	39.51
C_2	40.74	48.26	41.81	43.60	46.44	29.15	46.51	40.70
Mean	43.73	48.91	42.91		40.00	39.81	40.45	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		9.92	19.91			8.54	17.13	

At 30 DAS in the 1st year the interaction between manurial forms and biofertilizer and/or organic spray did not show significance [Table 4.20.3(b)]. The maximum and minimum values were respectively registered in treatment FC+VC with PSB+Rhz and PSB+CU (57.96 and 40.26 respectively).

In the 2nd year the treatment PSB+Rhz recorded significantly higher value than the treatment FC+PM with PSB+Rhz (48.29 and 29.15 respectively).

Table 4.20.3(c) Effect of interaction of manurial forms and biofertilizer and/or organic spray on nodule count of greengram (number/plant) at 45 DAS

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	40.26	36.81	33.29	36.79	33.07	36.92	40.22	36.74
C_1	28.92	46.07	49.44	41.48	40.22	39.81	36.92	38.98
C_2	39.51	30.81	31.11	33.81	37.63	34.14	54.92	42.23
Mean	36.23	37.90	37.95		36.97	36.96	44.02	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		7.17	14.38			7.52	15.08	

At 45 DAS in the 1st year the treatment FC+VC with PSB+CU produced markedly higher number of nodules than treatment PSB+CU alone (49.44 and 33,29 respectively). The treatment FC+VC with PSB+Rhz (46.07) was comparable with the most effective treatment combination [Table 4.20.3(c)].

In the 2nd year the treatment FC+PM with PSB+CU registered significantly higher number of nodules than treatment FC+PM alone (54.92 and 37.63 respectively).

4.6.3 Yield attributes and yield

4.6.3.1 Fertilizer levels

The varying levels of fertilizer influenced the yield attributes of greengram crop component in the system (Table 4.21). The pod count per plant (84.06), seeds per pod (11.44), seed yield (1503.00 kg ha^{-1}) and biological yield (7626.00 kg ha^{-1}) in the 2nd year and the test weight of seeds in both the years (34.95 and 35.34 g respectively) were significantly higher in treatment 100% RDF than the 0 level combination. Statistical comparability was noticed in the treatment 33% RDF for all parameters except the biological yield.

Table 4.21 Effect of INM on economic and biological yield of greengram during 1997-98 and 1998-99

Factors	Pods/plant		Seeds/pod		Test weight (g)		Seed yield (kg ha^{-1})		Biological yield (kg ha^{-1})	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Fertilizer levels (F):										
F_0	59.28	70.52	7.32	10.57	33.76	33.63	741.00	1068.00	3705.00	3543.10
F_1	66.67	80.67	7.88	11.31	34.63	34.93	859.40	1512.00	4297.00	6674.00
F_2	67.44	84.06	7.33	11.44	34.95	35.34	752.00	1503.00	3760.00	7626.00
	NS	*	NS	*	*	*	NS	*	NS	*
Forms of manure (C):										
C_0	61.91	72.39	7.25	10.94	34.04	34.31	719.20	1313.00	3596.00	5366.00
C_1	64.62	79.61	7.66	11.19	34.67	34.87	895.30	1292.00	4476.00	6212.00
C_2	66.85	83.24	7.62	11.20	34.63	34.72	737.80	1477.00	3689.00	6265.00
	NS	*	NS	NS	NS	NS	*	NS	*	*
Biofertilizer &/or organic spray (B):										
B_0	52.35	77.63	7.18	10.67	34.07	34.28	712.20	1235.00	3576.00	5675.00
B_1	69.14	79.65	7.60	11.57	34.49	34.60	806.40	1367.00	4032.00	6007.00
B_2	71.89	73.96	7.76	11.09	34.78	35.02	830.60	1481.00	4153.00	6161.00
	*	NS	NS	NS	NS	*	NS	*	NS	NS
SEd ±	5.391	4.304	2.915	0.242	0.473	0.279	66.41	103.98	332.08	96.95
CD (0.05)	10.820	8.638	-	0.487	0.950	0.560	133.27	208.66	666.36	194.55
FxC FxB CxB:										
SEd ±	9.3390	7.456	0.505	0.420	0.820	0.484	115.00	180.10	575.20	167.90
CD (0.05)	18.743	14.964	1.013	0.844	1.646	0.971	230.80	361.46	1154.42	336.97

*Significant at P = 0.05 NS = non-significant

4.6.3.2 Manurial forms

The manurial forms markedly affected some of the yield attributes (Table 4.21). The pod count (83.24) in the 2nd year was significantly higher in treatment FC+PM and the value in treatment FC+VC (79.61) was statistically comparable. The seed and biological yields (895.30 and 4476.00 kg ha^{-1}) in the 1st year were markedly higher in treatment FC+VC. However, the biological yield was significantly higher in the treatment FC+PM and the figure obtained in treatment FC+VC was on par (6265.00 and 6212.00 kg ha^{-1} respectively).

4.6.3.3 Biofertilizer and/or organic spray

The factor biofertilizer and/or organic spray markedly influenced more than one yield attribute (Table 4.21). In the 1st year the pod count per plant was significantly higher in treatment PSB+CU, and the treatment PSB+Rhz showed comparabilty (71.89 and 69.14 respectively). The Test weight & seed yield values in the 2nd yr were significantly higher in treatment PSB+CU. The maximum values in all other parameters were registered in either of the treatments PSB+CU and PSB+Rhz.

4.6.3.4 Interaction effect due to fertilizer levels and manurial forms

Table 4.21.1(a) Effect of interaction of fertilizer levels and manurial forms on pod count of greengram (number/plant) at harvest

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	53.89	58.33	65.61	59.28	56.22	72.61	82.72	70.52
F_1	64.83	74.89	60.28	66.67	79.67	79.33	83.00	80.67
F_2	67.00	60.64	74.67	67.44	81.28	86.89	84.00	84.06
Mean	61.91	64.62	66.85		72.39	79.61	83.24	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		9.34	18.74			7.46	14.96	

In the 1st year the interaction between fertilizer levels and manurial forms produced significantly higher pod count per plant [Table 4.21.1(a)]. The pods per plant was significantly higher in treatment 33% RDF with FC+VC than in control (74.89 and 53.89 respectively). Treatment 100% RDF with FC+PM was comparable (74.67).

In the 2nd year the pod count was significantly higher in the treatment 100% RDF with FC+VC than the control plot (86.89 and 56.22 respectively). All other treatments were statistically on par with the most effective treatment.

In the 1st year the seeds per pod was markedly higher in treatment 33% RDF with FC+VC than in control (8.25 and 6.73 respectively). Values with parity were

noticed in treatment 33% RDF alone and 100% RDF with FC+PM combination [Table 4.21.1(b)].

Table 4.21.1(b) **Effect of interaction of fertilizer levels and manurial forms on seed count of greengram (number/pod) at harvest**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	6.74	7.66	7.59	7.33	9.56	10.44	11.72	10.57
F_1	8.00	8.26	7.40	7.89	11.56	11.39	11.00	11.32
F_2	7.03	7.07	7.89	7.33	11.72	11.72	10.89	11.44
Mean	7.26	7.66	7.63		10.95	11.18	11.20	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.51	1.01			0.42	0.84	

In the 2nd year the values were markedly higher in treatments 100% RDF alone and with FC+VC and FC+PM alone than in FC+VC alone, which in turn was superior over control (11.72 in all the three treatments, 10.44 and 9.55 respectively). The treatments 33% RDF alone and with FC+VC (11.56 and 11.39 respectively) were at par with the most effective treatments.

Table 4.21.1(c) **Effect of interaction of fertilizer levels and manurial forms on test weight (g) of greengram at harvest**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	32.71	34.21	34.36	33.76	32.16	34.13	34.60	33.63
F_1	34.44	35.03	34.42	34.63	34.94	35.18	34.67	34.93
F_2	34.96	34.78	35.11	34.95	35.84	35.30	34.89	35.34
Mean	34.04	34.67	34.63		34.31	34.87	34.72	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.82	1.65			0.48	0.97	

The test weight value in the 1st year was significantly higher in treatment combination 100% RDF with FC+PM than in the control plot (35.11 and 32.71 g respectively). Statistical parity was noticed in all but treatments FC+PM alone and FC+VC alone [Table 4.21.1(c)].

In the 2nd year the treatment 100% RDF alone registered significantly higher figures than the treatment 100% RDF with FC+PM (35.84 and 34.89 g respectively). However, treatments 100% RDF with FC+VC, 33% RDF alone and with FC+VC were statistically at par with the treatment 100% RDF alone.

In the 1st year the treatment 33% RDF with FC+VC recorded significatly higher seed yield than the treatment 100% RDF alone (960.00 and 674.00 kg ha^{-1} respectively). No other treatment showed statistical significance [Table 4.21.1(d)].

Table 4.21.1(d) **Effect of interaction of fertilizer levels and manurial forms on seed yield of greengram (kg ha^{-1}) at harvest**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	671.90	883.50	667.40	740.93	921.40	1001.00	1283.00	1068.47
F_1	811.60	960.00	806.60	859.40	1405.00	1546.00	1583.00	1511.33
F_2	674.20	842.30	739.40	751.97	1611.00	1330.00	1566.00	1502.33
Mean	719.23	895.27	737.80		1312.47	1292.33	1477.33	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		115.00	230.81			180.10	361.46	

In the 2nd year the treatment 100% RDF registered significantly higher seed yield than the 0 level combination (1611.00 and 921.00 kg ha^{-1}). All other treatments except FC+VC alone were statistically on par with the most effective treatment.

Table 4.21.1(e) **Effect of interaction of fertilizer levels and manurial forms on biological yield of greengram (kg ha^{-1}) at harvest**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	3360.00	4417.00	3337.00	3704.67	3312.00	3582.00	3735.00	3543.00
F_1	4058.00	4800.00	4033.00	4297.00	5624.00	7379.00	7020.00	6674.33
F_2	3371.00	4212.00	3697.00	3760.00	7162.00	7677.00	8040.00	7626.33
Mean	3596.33	4476.33	3689.00		5366.00	6212.67	6265.00	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		575.20	1154.43			167.90	336.98	

In the 1st year the data pertaining [Table 4.21.1(e)] to biological yield of greengram crop in the system as influenced by the interaction of fertilizer levels and manurial forms showed that the treatment 33% RDF with FC+VC was markedly superior over the treatment 100% RDF alone (4800.00 and 3371.00 kg ha^{-1} respectively). However, no other treatments showed significant influence.

The data in the 2nd year showed significantly higher value in 100% RDF with FC+PM (8040.00 kg ha^{-1}) and was significantly above all treatment combinations. The treatments 33% RDF with FC+VC and with FC+PM were statistically at par with treatment 100% RDF alone (7379.00, 7020.00 and 7162.00 kg ha^{-1} respectively).

The pod count of greengram in the system as influenced by the interaction of fertilizer levels and biofertilizer and/or organic spray showed [Table 4.21.2(a)] that treàtment 100% RDF with PSB+CU was significantly above the 0 level treatment (75.28 and 39.06 respectively). All other treatments were statistically comparable with the most effective treatment.

4.6.3.5 Interaction effect due to fertilizer and biofertilizer and/or organic spray

Table 4.21.2(a) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on pod count of greengram (number/plant) at harvest

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	39.06	71.28	67.50	59.28	60.83	72.94	77.78	70.52
F_1	60.06	67.06	72.89	66.67	89.61	78.61	73.78	80.67
F_2	57.94	69.09	75.28	67.44	82.44	87.39	82.33	84.05
Mean	52.35	69.14	71.89		77.63	79.65	77.96	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		9.34	18.74			7.46	14.96	

In the 2nd year the treatment 33% RDF alone showed significantly higher pod count (89.61) than other treatment combinations. The minimum value was recorded in the control plot (60.83).

Table 4.21.2(b) Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on seed count of greengram (number/pod) at harvest

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	6.55	7.70	7.74	7.33	9.39	11.44	10.89	10.57
F_1	7.63	8.15	7.89	7.89	10.94	11.61	11.39	11.31
F_2	7.37	6.96	7.66	7.33	11.67	11.67	11.00	11.45
Mean	7.18	7.60	7.76		10.67	11.57	11.09	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.51	1.01			0.42	0.84	

In the 1st year the number of seeds per pod was highest in treatment 33% with PSB+Rhz (8.14) and was significantly above all treatments [Table 4.21.2(b)]. The minimum value was recorded in the 0 level treatment (6.55).

In the 2nd year treatment 100% RDF with PSB+Rhz produced the maximum number of seeds per pod and was significantly higher than the 0 level treatment (11.67 and 9.39 respectively). All other treatments were statistically comparable with the treatment 100% RDF with PSB+Rhz.

In the 1st year the test weight of seeds of greengram in the system showed that all the treatments registered [Table 4.21.2(c)] par values with the treatment with highest test weight (35.46 g), i.e., 100% RDF alone which was superior to the control plot (32.02 g).

Table 4.21.2(c) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on test weight of greengram (number/plant) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	32.02	34.39	34.86	33.76	33.04	33.67	34.18	33.63
F_1	34.72	34.78	34.38	34.63	34.52	35.14	35.13	34.93
F_2	35.46	34.29	35.09	34.95	35.27	34.99	35.76	35.34
Mean	34.07	34.49	34.78		34.28	34.60	35.02	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.82	1.65			0.48	0.97	

However, in the 2nd year only the treatment 100% RDF with PSB+CU recorded significantly higher value than the 0 level combination (35.76 and 33.04 g respectively). Interaction was non-significant with other treatment combinations.

Table 4.21.2(d) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on seed yield of greengram (kg ha^{-1}) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	573.50	741.00	908.40	740.97	926.10	1143.00	1136.00	1068.37
F_1	854.20	975.80	748.10	859.37	1351.00	1620.00	1564.00	1511.67
F_2	718.00	702.60	835.40	752.00	1428.00	1338.00	1742.00	1502.67
Mean	715.23	806.47	830.63		1235.03	1367.00	1480.67	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		115.00	230.81			180.10	361.46	

In the 1st year the treatment 33% RDF with PSB+Rhz was observed to be highly significant over treatment PSB+Rhz alone (975.80 and 741.00 kg ha^{-1}). The minimum value of 573.50 kg ha^{-1} was recorded in the control [Table 4.21.2(d)].

In the 2nd year the treatment 100% RDF with PSB+CU recorded maximum value with statistical significance over other treatment combinations. The minimum value was recorded in the control plot.

Table 4.21.2(e) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on biological yield of greengram (kg ha^{-1}) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	2867.00	3705.00	4542.00	3704.67	3324.00	3772.00	3532.00	3542.67
F_1	4271.00	4879.00	3741.00	4297.00	6132.00	6737.00	7154.00	6674.33
F_2	3590.00	3513.00	4177.00	3760.00	7570.00	7513.00	7795.00	7626.00
Mean	3576.00	4032.33	4153.33		5675.33	6007.33	6160.33	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		575.20	1154.43			167.90	336.98	

In the 1st year trends in biological yield were observed to be similar to that in grain yield [Table 4.21.2(e)]. Treatment 33% RDF with PSB+Rhz (4879.00 kg ha^{-1}) recorded highest and significant values over other treatment combinations. The minimum value of 2867.00 was observed in the control plot.

In the 2nd year the values of biological yield in treatment 100% RDF with PSB+CU were significantly higher than treatment 33% RDF with PSB+Rhz, which in turn was significantly higher than treatment 33% RDF with PSB+CU (7795.00, 7154.00 and 6737.00 respectively). Treatments 100% RDF alone and with PSB+Rhz (7570.00 and 7513.00 respectively) were statistically comparable.

4.6.3.6 Interaction effect due to manurial forms and biofertilizer and/or organic spray

Table 4.21.3(a) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on pod count of greengram (number/plant) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	45.67	70.67	69.39	61.91	62.39	71.50	83.28	72.39
C_1	52.56	68.81	72.50	64.62	88.89	82.83	67.11	79.61
C_2	58.83	67.94	73.78	66.85	81.61	84.61	83.50	83.24
Mean	52.35	69.14	71.89		77.63	79.65	77.96	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		9.34	18.74			7.46	14.96	

In the 1st year the pod count of greengram as influenced by the interaction between manurial forms and biofertilizers showed [Table 4.21.3(a)] that the treatment FC+PM with PSB+CU was significantly higher than the control plot (73.78 and 45.67 respectively).

In the 2nd year the count of pods per plant in FC+VC with PSB+CU, PSB+Rhz and control was observed to be non-significant in comparison to other treatment combinations. Treatment FC+VC alone recorded maximum pod count (88.89).

In both the cropping years the number of seeds per pod were significantly influenced by the interaction of manurial forms and biofertilizer and/or organic spray [Table 4.21.3(b)]. In the 1st year all treatments proved to be effective in producing significantly higher number of seeds per pod than the 0 level combination. The maximum and minimum values were registered respectively in treatments PSB+CU alone (7.85) and 0 level (6.36).

Table 4.21.3(b) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on seed count of greengram (number/pod) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	6.37	7.55	7.85	7.26	9.78	11.83	11.22	10.94
C_1	7.51	7.66	7.81	7.66	10.89	11.28	11.39	11.19
C_2	7.66	7.59	7.63	7.63	11.33	11.61	10.67	11.20
Mean	7.18	7.60	7.76		10.67	11.57	11.09	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.51	1.01			0.42	0.84	

In the 2nd year, the treatment PSB+Rhz alone obtained the highest figure (11.83). However, the treatments FC+PM alone and with PSB+Rhz, FC+VC with PSB+CU and with PSB+Rhz and PSB+CU alone registered par values. The minimum value of 9.77 was produced by control.

Table 4.21.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on test weight (g) of greengram at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	34.14	33.41	34.55	34.03	33.83	34.28	34.83	34.31
C_1	34.05	35.22	34.74	34.67	34.57	34.67	35.37	34.87
C_2	34.01	34.83	35.05	34.63	34.43	34.86	34.87	34.72
Mean	34.07	34.49	34.78		34.28	34.60	35.02	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.82	1.65			0.48	0.97	

In the 1st year treatment FC+VC with PSB+Rhz was found to be significant over other treatment combinations [Table 4.21.3(c)]. Treatment PSB+Rhz alone recorded least value (33.41). Other treatment combinations were at par with each other.

In the 2nd year treatment FC+VC with PSB+CU proved to be most effective and produced significantly higher value (35.37 g) of test weight than other treatments. The minimum value was recorded in 0 level combination (33.83 g).

Table 4.21.3(d) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on seed yield of greengram (kg ha^{-1}) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	580.40	723.40	853.90	719.23	1069.00	1354.00	1515.00	1312.67
C_1	811.40	837.70	1037.00	895.37	1274.00	1295.00	1309.00	1292.67
C_2	753.90	858.30	601.30	737.83	1362.00	1453.00	1617.00	1477.33
Mean	715.23	806.47	830.73		1235.00	1367.33	1480.33	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		115.00	230.81			180.10	361.46	

In the 1st year highest seed yield was recorded [Table 4.21.3(d)] in treatment FC+VC with PSB+CU followed by treatment FC+PM with PSB+Rhz (1037.00 and 858.30 kg ha^{-1} respectively) both of which were comparable and significantly higher than other treatment combinations.

In the 2nd year the interactive effect of manurial forms and biofertilizer and/or organic spray on seed yield was significantly high in treatments FC+PM with PSB+CU and PSB+Rhz and PSB+CU alone (1617.00, 1453.00 and 1515.00 kg ha^{-1} respectively). Control plot recorded the least yield of 1069.00 kg ha^{-1}.

Table 4.21.3(e) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on biological yield of greengram (kg ha^{-1}) at harvest**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	2902.00	3617.00	4269.00	3596.00	4472.00	5789.00	5836.00	5365.67
C_1	4057.00	4188.00	5184.00	4476.33	6428.00	6013.00	6196.00	6212.33
C_2	3769.00	4291.00	3006.00	3688.67	6125.00	6220.00	6450.00	6265.00
Mean	3576.00	4032.00	4153.00		5675.00	6007.33	6160.67	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		575.20	1154.43			167.90	336.98	

In the 1st year significant interaction on biological yield was noticed only in treatment FC+VC with PSB+CU (5184.00 kg ha^{-1}). The minimum yield of 2902.00 kg ha^{-1} was observed in the control plot [Table 4.21.3(e)].

In the 2nd year the biological productivity recorded significant interactions in treatments FC+PM with PSB+CU and with PSB+Rhz, FC+VC alone and with PSB+CU. The maximum and minimum yields were observed in treatments FC+PM with PSB+CU (6450.00 kg ha^{-1}) and 0 level combination (4472.00 kg ha^{-1}).

4.6.4 Post-cropping soil status

4.6.4.1 Fertilizer levels

The varying fertilizer levels in the INM package administered to the greengram crop in the system influenced certain physico-chemical properties of the soil (Table 4.22). The pH in the 2nd year significantly lower in treatment 100% RDF than the 0 level and statistical comparability was observed in treatment 33% RDF (7.55 and 7.57 respectively).

The EC_{25} in both the years were markedly lower in treatment 33% RDF and the figures obtianed in 100% RDF were statistically at par (0.054 and 0.057 dS m^{-1} respectively in the 1st year and 0.234 and 0.236 dS m^{-1} respectively in the 2nd year).

In the 1st year the percentage organic carbon was significantly higher in treatment 33% RDF than control plot (0.350 and 0.268% respectively).

The available potassium status of the soil in the 1st year at the post-cropping stage was markedly higher in treatment 33% RDF and the value analysed in treatment 100% RDF was comparable (337.60 and 329.70 kg ha^{-1} respectively.

Though the soil analyses data on percentage organic carbon and available potassium in the 2nd year and available phosphorus in both years did not show any significant differences, the maximum values were registered in either of the treatments 100% RDF or 33% RDF levels.

4.6.4.2 Manurial forms

The soil analysis at the post cropping (greengram) stage showed (Table 4.22) that the EC_{25} was considerably lower in treatment FC+VC than the control and par values were obtained in treatment in FC+PM (0.052 and 0.055 dS m^{-1} respectively).

The percentage organic carbon was significantly higher in treatment FC+PM during the 1st year and in treatment FC+VC in the 2nd year and statistically comparability between the two treatments was noticed (0.366 and 0.306% respectively in the 1st year and 0.471 and 0.470 respectively in the 2nd year).

The analysis of available phosphorus showed significantly higher values in treatment FC+PM during the 1st year and treatment FC+VC in the 2nd year. Statistical parity between the two treatments was observed (33.59 and 28.33 kg ha^{-1} respectively in the 1st year and 41.52 and 40.81 kg ha^{-1} respectively in the 2nd year).

The available potassium status in the 1st year was markedly higher in treatment FC+VC than 0 level (343.50 and 293.20 kg ha^{-1}). In the 2nd year the maximum and minimum values were respectively registered in treatments FC+PM and control plot (378.40 and 339.40 kg ha^{-1}).

Table 4.22 Effect of greengram cropping under INM system on the Physico-chemical properties of the soil

Factors	pH		EC_{25} ($dS\ m^{-1}$)		Organic Carbon (%)		Available Phosphorus ($kg\ ha^{-1}$)		Available Potassium ($kg\ ha^{-1}$)	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Fertilizer levels (F):										
F_0	8.34	7.62	0.076	0.266	0.268	0.401	25.56	36.81	291.30	345.50
F_1	8.31	7.57	0.054	0.234	0.350	0.420	29.81	41.26	337.60	376.80
F_2	8.28	7.55	0.057	0.236	0.328	0.451	22.78	34.59	329.70	336.20
	NS	*	*	*	*	NS	NS	NS	*	NS
Forms of manure (C):										
C_0	8.34	7.58	0.078	0.251	0.275	0.331	16.22	30.33	293.20	339.40
C_1	8.30	7.57	0.052	0.256	0.306	0.471	28.33	41.52	343.50	340.70
C_2	8.28	7.58	0.055	0.229	0.366	0.470	33.59	40.81	321.90	378.40
	NS	NS	*	*	*	*	*	*	*	NS
Biofertilizer &/or organic spray (B):										
B_0	8.33	7.58	0.079	0.255	0.255	0.397	24.11	30.59	279.40	325.70
B_1	8.27	7.57	0.054	0.233	0.322	0.432	27.37	41.07	337.30	392.30
B_2	8.33	7.58	0.054	0.248	0.370	0.443	26.67	41.00	341.90	340.50
	NS	NS	*	NS	*	NS	NS	*	*	NS
SEd ±	0.0431	0.194	0.0019	0.0120	0.0327	0.0340	4.419	4.555	18.498	29.130
CD (0.05)	-	0.3890	0.0038	0.0240	0.0656	0.0680	8.859	9.141	37.119	-
FxC FxB CxB:										
SEd ±	0.0740	0.0337	0.0033	0.0208	0.0566	0.0589	7.647	7.891	32.040	50.460
CD (0.05)	0.1498	0.0676	0.0067	0.0419	0.1137	0.1183	15.340	15.830	64.300	101.27

*Significant at P = 0.05 NS = non-significant

4.6.4.3 Biofertilizer and/or organic spray

The EC_{25} value in the 1st year was remarkably lower (Table 4.22) in treatments PSB+CU and PSB+Rhz (0.054 dS m^{-1} in both) than the 0 level (0.079 dS m^{-1}).

The percentage organic carbon and available potassium in the 1st year were significantly higher in treatment PSB+CU (0.370% and 341.90 kg ha^{-1} respectively) than 0 level and statistical parity in treatment PSB+Rhz was noticed (0.322% and 337.30 kg ha^{-1} respectively).

4.6.4.4 Interaction effect due to fertilizer levels and manurial forms

Table 4.22.1(a) **Effect of interaction of fertilizer levels and manurial forms on post-cropping (greengram) EC_{25} status of soil (dS m^{-1})**

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.118	0.054	0.056	0.076	0.306	0.266	0.228	0.266
F_1	0.056	0.051	0.056	0.054	0.229	0.243	0.232	0.235
F_2	0.063	0.053	0.056	0.057	0.219	0.261	0.229	0.236
Mean	0.079	0.053	0.056		0.251	0.257	0.230	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.003	0.007			0.021	0.042	

In the 1st year the interaction between fertilizer levels and manurial forms influenced the EC_{25} status of soil [Table 4.22.1(a)] and treatments FC+VC alone, with 33% RDF and with 100% RDF (0.054, 0.051 and 0.053 dS m^{-1} respectively) were comparable and significantly lower than treatment 100% RDF alone (0.063 dS m^{-1}), which in turn was superior to 0 level combination (0.118 dS m^{-1}).

In the 2nd year the minimum values were recorded in treatment 100% RDF (0.219 dS m^{-1}) alone which was remarkably lower than the control (0.306 dS m^{-1}). Statistical comparability was noticed in several treatments including FC+PM and FC+VC with 33% RDF and 100% RDF.

In the 1st year the interaction of fertilizer levels and manurial forms produced markedly higher figures [Table 4.22.1(b)] in treatment FC+PM with 33% RDF and with 100% RDF (0.393 and 0.394% respectively). The minimum value (0.241%) was recorded in treatment FC+VC alone.

Table 4.22.1(b) Effect of interaction of fertilizer levels and manurial forms on post-cropping (greengram) organic carbon (%) status of soil

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	0.254	0.241	0.311	0.269	0.248	0.481	0.476	0.402
F_1	0.297	0.360	0.394	0.350	0.336	0.484	0.534	0.451
F_2	0.276	0.318	0.393	0.329	0.411	0.448	0.401	0.420
Mean	0.276	0.306	0.366		0.332	0.471	0.470	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.057	0.114			0.059	0.118	

In the 2nd year the treatment 33% RDF with FC+PM registered considerably higher value than treatment 100% RDF alone (0.534 and 0.411% respectively). The minimum value of 0.248% was observed in the 0 level combination.

Table 4.22.1(c) Effect of interaction of fertilizer levels and manurial forms on post-cropping (greengram) available P_2O_5 (kg ha^{-1}) status of soil

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	14.33	24.56	37.78	25.56	25.89	42.56	42.00	36.82
F_1	23.00	29.78	36.67	29.82	35.78	40.56	47.44	41.26
F_2	11.33	30.67	26.33	22.78	29.33	41.44	33.00	34.59
Mean	16.22	28.34	33.59		30.33	41.52	40.81	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		7.65	15.35			7.89	15.84	

In the 1st year the interactive effect due to fertilizer levels and manurial forms resulted in significantly increased available phosphorus status in the treatments FC+PM alone, 33% RDF with FC+PM and with FC+VC and 100% RDF with FC+VC [Table 4.22.1(c)].

In the 2nd year the treatment 33% RDF with FC+PM (47.44 kg ha^{-1}) registered significantly higher values than other treatments. The minimum figure of 25.89 kg ha^{-1} was noted in the 0 level combination.

Table 4.22.1(d) Effect of interaction of fertilizer levels and manurial forms on post-cropping (greengram) available K_2O (kg ha^{-1}) status of soil

Factors	1997-98				1998-99			
	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
F_0	262.10	302.00	309.80	291.30	261.00	339.10	436.40	345.50
F_1	316.90	366.20	329.60	337.57	379.20	384.10	367.20	376.83
F_2	300.60	362.20	326.40	329.73	378.00	299.00	331.60	336.20
Mean	293.20	343.47	321.93		339.40	340.73	378.40	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		32.04	64.30			50.46	101.27	

In the 1st year the maximum potassium availability in the soil at post cropping (greengram) stage was observed in treatment 33% RDF with FC+VC (366.20 kg ha^{-1}), which was significantly above other treatment combinations [Table 4.22.1(d)]. The minimum value of 262.10 kg ha^{-1} was recorded in the 0 level combination.

In the 2nd year the treatment FC+PM registered significant and highest value (436.40 kg ha^{-1}) of available potassium. The minimum value of 261.00 kg ha^{-1} was observed in the control plot.

4.6.4.5 Interaction effect due to fertilizer and biofertilizer and/or organic spray

Table 4.22.2(a) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (greengram) EC_{25} status of soil (dS m^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.123	0.053	0.052	0.076	0.303	0.248	0.248	0.266
F_1	0.054	0.054	0.053	0.054	0.244	0.216	0.244	0.235
F_2	0.060	0.054	0.058	0.057	0.219	0.237	0.253	0.236
Mean	0.079	0.054	0.054		0.256	0.233	0.249	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.003	0.007			0.021	0.042	

In the 1st year the EC_{25} as influenced by the interaction of fertilizer levels and biofertilizer and/or organic spray revealed [Table 4.22.2(a)] that the treatment PSB+CU alone registered significantly lower values than the treatment 100% RDF alone, which in turn was superior to the 0 level combination (0.052, 0.060 and 0.123 dS m^{-1} respectively). Treatments PSB+Rhz alone, 33% RDF alone, with PSB+Rhz and with PSB+CU, 100% RDF with PSB+Rhz and PSB+CU were statistically comparable with the most effective treatment.

In the 2nd year the treatment 33% RDF with PSB+Rhz recorded significantly lower values of EC_{25} than the 0 level combination (0.216 and 0.303 dS m^{-1}). Statistical parity in all other treatment combinations was noticed.

In the 1st year the data pertaining to the percentage organic carbon of the soil as influenced by the interaction showed [Table 4.22.2(b)] significantly higher figures in treatment 100% RDF with PSB+CU than in the control plot (0.398 and 0.199% respectively). Statistically par values were noted in treatments 33% RDF with PSB+Rhz and with PSB+CU (0.367 and 0.363%).

Table 4.22.2(b) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (greengram) organic carbon status of soil (%)**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	0.199	0.258	0.350	0.269	0.360	0.438	0.407	0.402
F_1	0.321	0.367	0.363	0.350	0.443	0.492	0.419	0.451
F_2	0.246	0.343	0.398	0.329	0.388	0.368	0.504	0.420
Mean	0.255	0.323	0.370		0.397	0.433	0.443	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.057	0.114			0.059	0.118	

In the 2nd year the treatment 100% RDF with PSB+CU registered significantly higher values of organic carbon than the control plot (0.504 and 0.360%). Treatment 33% RDF with PSB+Rhz (0.492%) was statistically at par with the most effective treatment.

Table 4.22.2(c) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (greengram) status of available P_2O_5 in soil (kg ha^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	23.00	28.11	25.56	25.56	31.78	41.89	36.78	36.82
F_1	25.33	33.67	30.44	29.81	34.22	39.89	49.67	41.26
F_2	24.00	20.33	24.00	22.78	25.78	41.44	36.56	34.59
Mean	24.11	27.37	26.67		30.59	41.07	41.00	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		7.65	15.35			7.89	15.84	

In the 1st year at post-cropping stage, the interaction between the fertilizer levels and biofertilizer and/or organic spray did not show any significant influence on the available phosphorus status of the soil samples [Table 4.22.2(c)]. The maximum and minimum values were respectively recorded in the treatments 33% RDF with PSB+Rhz and 100% RDF with PSB+Rhz (33.67 and 20.33 kg ha^{-1}).

In the 2nd year the treatment 33% RDF with PSB+CU registered significantly higher values over the 0 level combination (49.67 and 31.78 kg ha^{-1} respectively).

Table 4.22.2(d) **Effect of interaction of fertilizer levels and biofertilizer and/or organic spray on post-cropping (greengram) status of available K_2O in soil (kg ha^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
F_0	269.80	289.90	314.20	291.30	367.20	398.40	270.90	345.50
F_1	286.10	353.20	373.30	337.53	350.90	369.20	410.40	376.83
F_2	282.20	368.80	338.20	329.73	259.10	409.30	340.10	336.17
Mean	279.37	337.30	341.90		325.73	392.30	340.47	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		32.04	64.30			50.46	101.27	

In the 1st year the treatment 33% RDF with PSB+CU significantly increased the available potassium status of the soil [Table 4.22.2(d)] over the treatment PSB+Rhz alone (373.30 and 289.90 kg ha^{-1}). Statistically par values were recorded in treatment 100% RDF with PSB+Rhz (368.80 kg ha^{-1}).

In the 2nd year the interaction of the factors showed its influence, and the treatment 33% RDF with PSB+CU combination registered significantly high values of available potassium (410.40 kg ha^{-1}). The minimum figure of 259.10 kg ha^{-1} was noted in treatment 100% RDF alone.

4.6.4.6 Interaction effect due to manurial levels and biofertilizer and/or organic spray

Table 4.22.3(a) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (greengram) EC_{25} status of soil (dS m^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.124	0.056	0.057	0.079	0.284	0.227	0.242	0.251
C_1	0.059	0.050	0.050	0.053	0.247	0.262	0.261	0.257
C_2	0.054	0.057	0.057	0.056	0.236	0.211	0.242	0.230
Mean	0.079	0.054	0.054		0.256	0.233	0.249	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.003	0.007			0.021	0.042	

In the 1st year the interactive effect showed that the treatment combinations FC+VC with PSB+Rhz and with PSB+CU registered significantly lower values of EC_{25} than treatment FC+VC alone, which in turn was markedly lower than the control plot (0.050 in both and 0.124 dS m^{-1} respectively). All other treatment combinations were comparable with the most effective treatment [Table 4.22.3(a)].

In the 2nd year the treatment FC+PM with PSB+Rhz (0.211 dS m^{-1}) recorded significantly lower values than other treatment combinations. The maximum value of 0.284 dS m^{-1} was noted in the control plot

In the 1st year the interaction of manurial forms and biofertilizer and/or organic spray showed significant influence on the percentage organic carbon of the soil under greengram cropping [Table 4.22.3(b)]. The treatment FC+PM with PSB+CU combination recorded markedly higher value than the control plot (0.453 and 0.147% respectively).

Table 4.22.3(b) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (greengram) organic carbon status of soil (%)**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	0.147	0.268	0.412	0.276	0.241	0.394	0.359	0.331
C_1	0.356	0.318	0.246	0.306	0.474	0.473	0.466	0.471
C_2	0.263	0.382	0.453	0.366	0.476	0.430	0.506	0.470
Mean	0.255	0.323	0.370		0.397	0.433	0.443	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		0.057	0.114			0.059	0.118	

In the 2nd year the treatment combination FC+PM with PSB+CU showed markedly higher values than the treatment PSB+CU alone (0.506 and 0.359% respectively). The minimum value of 0.241% was noted in the 0 level combination.

Table 4.22.3(c) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (greengram) available P_2O_5 status of soil (kg ha^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	12.89	20.33	15.44	16.22	10.67	42.78	37.56	30.34
C_1	29.33	26.67	29.00	28.33	36.44	39.56	48.56	41.52
C_2	30.11	35.11	35.56	33.59	44.67	40.89	36.89	40.82
Mean	24.11	27.37	26.67		30.59	41.08	41.00	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		7.65	15.35			7.89	15.84	

The available phosphorus status of the post-cropping (greengram) soil sample revealed [Table 4.22.3(c)] that the treatments FC+PM with PSB+CU and with PSB+Rhz were comparable with each other (35.56 and 35.11 kg ha^{-1}) and were significantly higher than the control plot (12.89 kg ha^{-1}).

The interaction between the manurial forms and biofertilizer and/or organic spray was significant and superior to the control in the 2nd year. The maximum and minimum values were registered respectively in the treatment FC+VC with PSB+CU and the control plot (48.56 and 10.67 kg ha^{-1}).

The available potassium status showed significant interaction in the treatment FC+VC with PSB+CU combination (387.40 kg ha^{-1}), which was superior to other treatments [Table 4.22.3(d)]. The minimum value of 229.40 kg ha^{-1} was noted in the control.

Table 4.22.3(d) **Effect of interaction of manurial forms and biofertilizer and/or organic spray on post-cropping (greengram) available K_2O status of soil (kg ha^{-1})**

Factors	1997-98				1998-99			
	B_0	B_1	B_2	Mean	B_0	B_1	B_2	Mean
C_0	229.40	306.20	343.90	293.17	254.40	385.30	378.40	339.37
C_1	303.10	339.90	387.40	343.47	339.90	348.90	333.40	340.73
C_2	305.60	365.80	294.40	321.93	382.90	442.80	309.60	378.43
Mean	279.37	337.30	341.90		325.73	392.33	340.47	
		SEd ±	CD (0.05)			SEd ±	CD (0.05)	
		32.04	64.30			50.46	101.27	

In the 2nd year the treatment combination FC+PM with PSB+Rhz was found to be superior and significant over the control, the available potassium figures being 442.80 and 254.40 kg ha^{-1} respectively.

DISCUSSION

CHAPTER 5

DISCUSSION

The legume based cropping system can be exploited to maximize the per unit area productivity of drymatter, without impairing the fragile aspects of soil in any farming system. Cropping systems have altered the dynamics of soil fertility. Combined application of inorganic, organic and biological plant nutrient sources improves soil physico-chemical and biological condition. Organic recycling is of vital importance not only in augmenting the crop productivity targets of our present and future, but also to minimise the environmental pollution. The findings of the trials conducted have been briefly discussed here.

5.1 Experiment 1: (Soybean – Mustard – Fodder cowpea system) Crop component 1: Soybean

5.1.1 Dry matter accumulation

At most of the stages in the 1st and 2nd year, treatment combinations with 100% and 33% RDF showed significant difference in dry matter accumulation with respect to the control. Full dose of fertilizer application expressed maximum effect on dry matter accumulation with statistical parity in 33% RDF at certain stages (Fig.5.1.1). This is perhaps due to the fact that native fertility alone is not sufficient to sustain the crop.

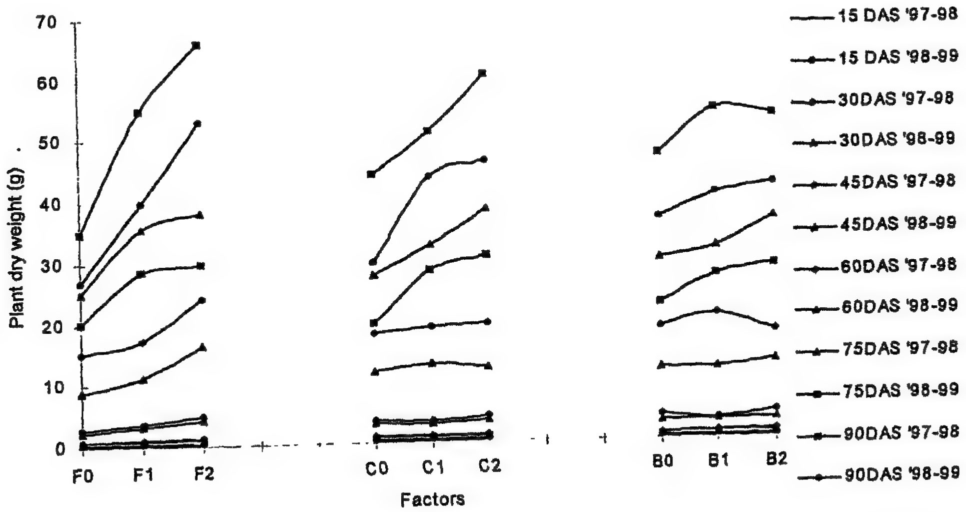


Fig 5.1.1 Effect of INM on dry weight of soybean (g/plant) at successive stages during 1997-98 and 1998-99

The dry weight due to manurial forms was higher at all the stages of crop growth and significantly higher at 75 and 90 DAS. This may be attributed to the slower but consistent availability of essential nutrients, particularly at the grain filling stage. Singh and Srivastava (1971) also reported that addition of organic amendments increased N availability. This is probably due to mineralization and reduced losses of N. Blondel (1971) also reported similar findings. Organic amendments enhanced N fixation in soybean, and increased the total N content in the crops.

The biofertilizer and/or organic spray treatment showed significance in the early and later stages of the crop. Higher dry matter accumulation in comparison to the control was observed during the entire experimental period. The response of soybean to the biofertilizer combinations with PSB+Rhz suggests that there is beneficial microbial activity in the rhizosphere. Application of PSB+CU may have enhanced the microbial activity and absorption of nutrients through the foliage. Ahmad and Jha (1982) reported increase in yield of soybean [*G. max* (L.) Merr.] due to inoculation with *Bacillus megaterium* and *B. circulants*. Tomar *et al.* in 1994 stated that phosphate-solubilizing bacteria increased the efficiency of applied phosphate and crop response, when the seed was treated with the inoculants.

On critical examination, a positive interaction between the fertilizer levels and the manurial forms in increasing the dry matter accumulation was observed. The interaction effect between the fertilizer levels and biofertilizer on dry matter accumulation due to 100% and 33% RDF levels in combination with either of the biofertilizers, expressed significant enhancement. Application of manurial forms and biofertilizer and/or organic spray also showed synergistic effect on the growth of the crop.

Shroff in 1994 opined that phosphate solubilising microorganisms help in minimising the phosphorus fixation as it mineralizes native phosphorus. Combined application of fertilizers, *Rhizobium* and phosphorus solubilizing microorganisms had enhanced the yield of soybean significantly.

5.1.2 Root nodulation

Treatment 33% RDF influenced the nodulation pattern of soybean in the cropping system at most of the stages in the growing period. This is perhaps due to the fact that nodulation is enhanced at lower soil nitrogen content. In multilocational trials,

pearlmillet and other crops have revealed better inoculation response with no or low levels of N fertilizers, Alagawadi (1998).

Nodulation was observed to be lower in beginning but gradually increased with crop growth in plots where FC+PM or FC+VC were applied. This behaviour may be due to progressive improvement of soil physical properties congenial to nodulation. Moharram *et al.* (1999) found that soil biomass increased with increasing compost rates, while soil organic matter, total C and available N contents were increased over the control, particularly with inoculation.

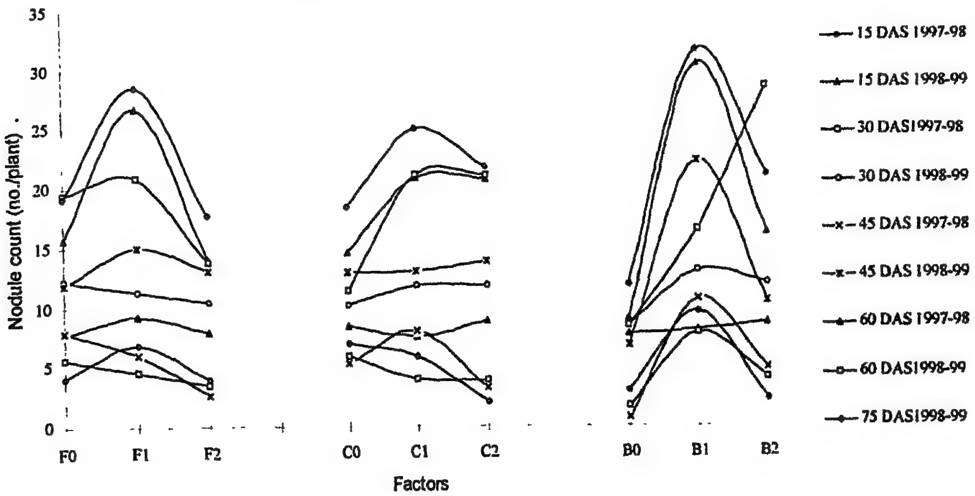


Fig. 5.1.2 Effect of INM on nodulation of soybean (number/plant) during 1997-98 and 1998-99

Treatment PSB+Rhz showed significantly higher nodule count than the control at all stages (Fig. 5.1.2). Soil phosphorus utilisable by microorganisms and inoculation of *Rhizobium japonicum* may have considerably increased nodulation. Moharram *et al.* (1999) found that Bradyrhizobium + compost significantly increased nodule numbers, plant dry weight, N yield and N fixation compared with uninoculated plants.

Interaction of fertilizer dosage of 33% RDF with manurial forms greatly influenced the nodulation in soybean. Among manurial combinations, FC+VC showed slightly higher figures than FC+PM combination. The fertilizer and biofertilizer and/or organic spray interaction showed that the optimal combination was 33% RDF with PSB+Rhz. The interaction effect of manurial forms and biofertilizers revealed that FC+VC with PSB+Rhz was the most compatible combination. Hsieh and Hsu (1995) observed that vegetable soybean performed best with pig manure compost with microorganism mixture containing nitrogen-fixers, PSB and VAM.

5.13 Yield attributes

The yield attributes showed positive response to the higher level of fertilizer and comparable figures were obtained in treatment 33% RDF. Higher percentage of carbohydrate and oil content in the seed was however, noticed in the lower dose of fertilizer. The maximum protein content was obtained in treatment with the 100% RDF treatment (Table 4.03). Research conducted by other workers has shown that about 50% reduction in the RDF is possible, particularly when compensated with other forms of nutrient carriers. Bachav and Sabale (1996) observed that the seed yield, seed protein and oil contents were highest with 50% each of urea and FYM.

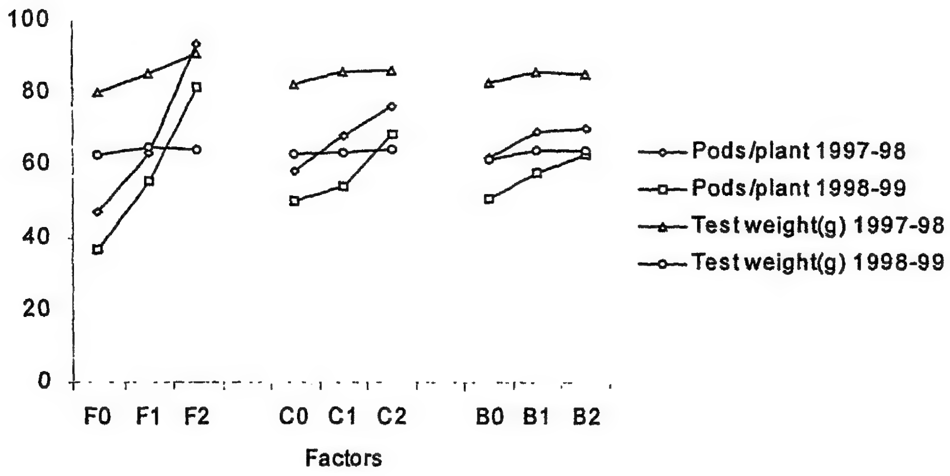


Fig. 5.1.3 **Effect of INM on pods/plant and test weight of soybean**

The manurial form FC+PM proved to be a suitable alternative in the INM package for increasing the productivity potential and protein yield of soybean in the cropping system (Fig. 5.1.3). The FC+VC combination was found to be comparable with regard to seed yield. The trend has been in conformity with work done on other crops like wheat (Ranwa and Singh, 1999). The fertilizer constituent in the interaction contributed more to the carbohydrate and oil in soybean seed.

The biofertilizer and/or organic spray component in the INM package showed significant influence on the pod count, seed yield, protein and oil content in seed of soybean (Table 4.03). It helps in better sustenance of soybean in the cropping system than with the use of fertilizers alone. These findings are in accordance with those of Dahatonde and Shava (1992) and Ramamurthy and Shivshankar (1996).

The interaction effect of fertilizer levels and manurial forms on pod count, test weight, seed yield and biological yield was positive. Treatment FC+PM showed maximum and significant interaction with respect to the zero level. FC+VC was comparable to FC+PM in all yield attributes. The interaction between fertilizer levels and biofertilizer and/or organic spray registered significant effect on the yield attributes (Fig. 5.1.4). Lower level of fertilizer with inoculation of phosphate solubilizers coupled with organic spray expressed increase in carbohydrate content of soybean seed. This may be attributed to the role of P in synthesizing ATP in photosynthesis.

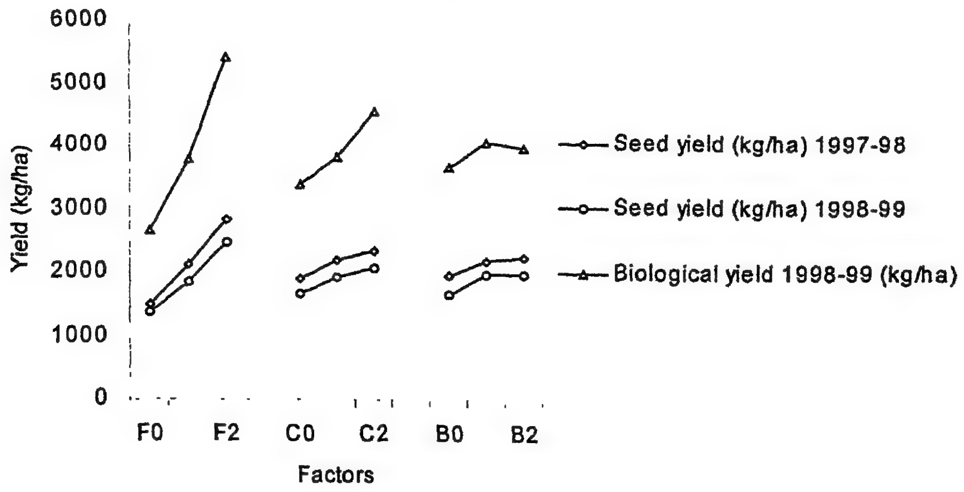


Fig. 5.1.4 Effect of INM on economic and biological yield of soybean

Manurial forms and biofertilizers expressed significant interactional effect on all the yield parameters and on the qualitative aspects, *viz.*, protein and oil content in seed of soybean. Similar findings were reported by Jain et al. in 1995. Highest pod count was registered in plots treated with combinations containing FC+PM as a component. Boldness of seed was maximum in plots treated with FC+PM with PSB+Rhz. This may be attributed to the increased availability of phosphorus as a result of the inoculation. Jayapaul and Ganesaraja (1990) reported increased test weight due to application of phosphorus.

5.14 Post cropping soil physico-chemical status

The variation in the fertilizer dosage influenced physico-chemical properties of soil analysed at the post harvest stage. Fertilizer applied @ 33% RDF to the soybean crop in the system was found to be sufficient for the maintenance of soil physico-chemical characteristics. The manurial form FC+VC significantly reduced the EC_{25} and FC+PM combination increased organic carbon, P_2O_5 and K_2O in soil [Fig. 5.1.5 (a &

b)]. Increase in K_2O status due to poultry manure may be attributed to its higher K content. Decrease in EC_{25} may be explained by high adsorption of organic matter. Among the biofertilizers, treatment PSB+CU was noted as the contributing factor in the maintenance of optimal soil properties during both the years.

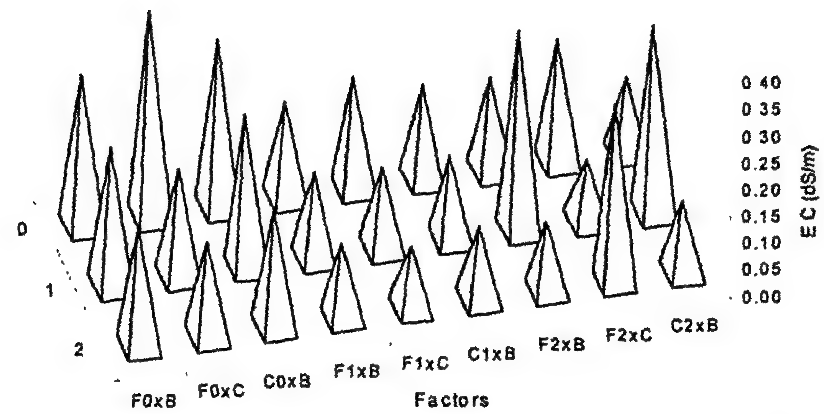


Fig 5.1.5(a) **Effect of interaction of fertilizer levels, manurial forms and biofertilizer &/or organic spray in soybean cropping on EC_{25} (dS m^{-1}) of soil during 1997-98**

Addition of organic sources has considerably increased the soil organic carbon content with respect to the control in all treatments. This supports the increase in yield attributes of the crop in plots treated with organic sources. Similarly the available potassium and phosphorus status of soil was also improved.

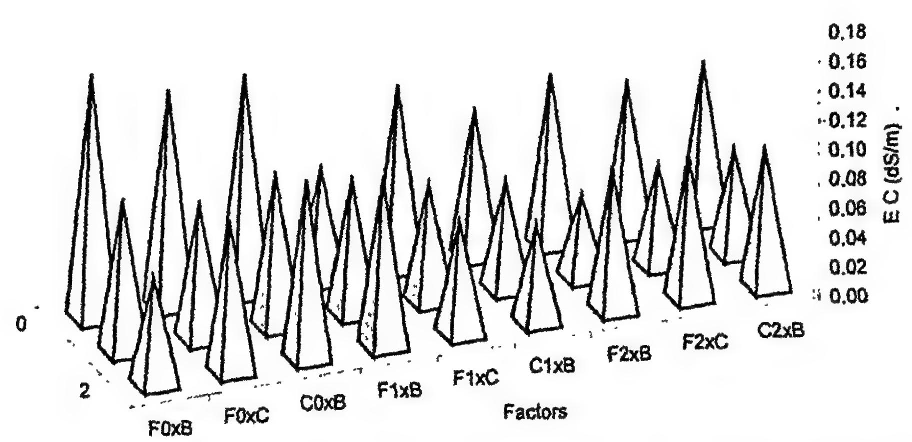


Fig 5.1.5(b) **Effect of interaction of fertilizer levels, manurial forms and biofertilizer &/or organic spray in soybean cropping on EC_{25} (dS m^{-1}) of soil during 1998-99**

The interactive effect between fertilizer levels, manurial forms and biofertilizer and/or organic spray was negative for EC_{25} but positve for organic carbon, available phosphorus and potassium. However, Dubey and Verma (1999) observed that the pH and EC_{25} values of the soil were not significantly influenced by the different treatments. The soil organic carbon increased by 51% under FYM application as compared to the initial value of 0.45%. Gopalkrishnan and Palaniappan in 1992 reported that after harvest of soybean FYM applied plots had medium available N and high available P as compared to no FYM treatment. However, application of FYM did not show any significant effect on the soil available K.

5.2 Experiment 1: (Soybean – Mustard – Fodder cowpea system) Crop component 2: Mustard

5.2.1 Dry matter accumulation

The inorganic fertilizer application has shown positive effect on the dry matter accumulation pattern of mustard crop in the system. Though higher doses showed increased dry matter content, not much variation was observed with decreased dose of inorganic fertilizer in certain crop stages (Fig. 5.2.1). Thakur and Chand (1998) also reported similar response. Organic sources of nutrient carrier expressed maximum dry matter accumulation in most of the stages of the crop. Either of the treatments FC+PM or FC+VC proved to be effective in maintaining higher plant dry weight.

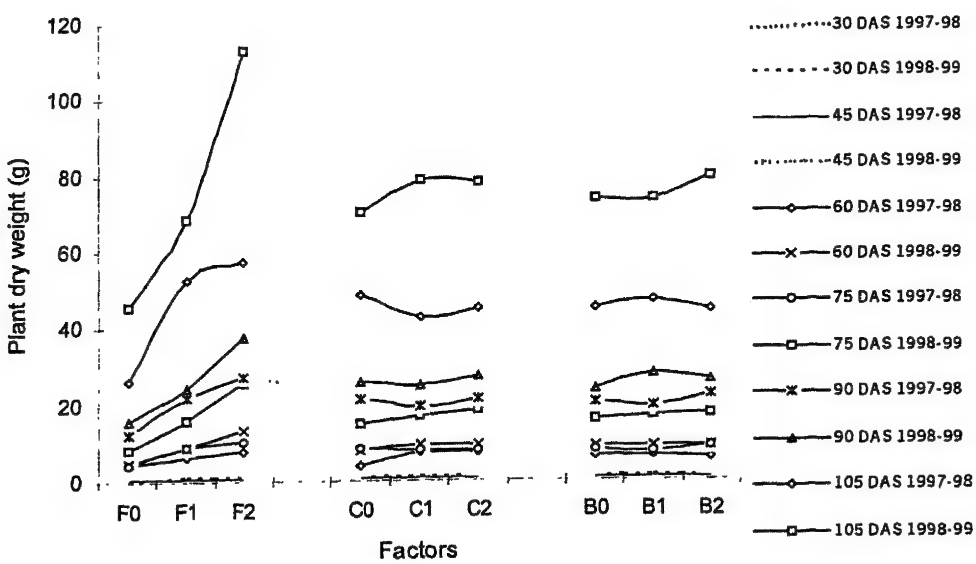


Fig. 5.2.1 Effect of INM on dry weight of mustard (g/plant) during 1997-98 and 1998-99

Biofertilizer and/or organic spray increased the dry matter content towards the later stages in mustard. This may be attributed to the growth promoting characteristics of foliar application of cow's urine. The positive response to crop plants to *Azospirillum* inoculation could also be ascribed to hormonal effects and enhanced nutrient uptake. In pure cultures, *Azospirillum* is known to produce IAA, GA and cytokinin like substances, Alagawadi (1998).

Positive interactive effect of inorganic fertilizers and organic manures was evident at most of the stages of the experiment. The organic component in the INM package enhanced the overall performance and hence could be suitably incorporated in the production technology of mustard. Dravid and Goswami in 1988 observed similar positive effects of integration of chemical fertilizers with organic manures. The interaction of biofertilizer and/or organic spray with inorganic fertilizer and with manurial forms has also shown a similar trend as above.

5.2.2 Yield attributes

Effect of inorganic fertilizer doses on all yield parameters was superior to the control. Increasing doses of fertilizer progressively showed increased values of yield contributing factors. However, the quality parameter like oil [illegible] content registered higher values at lower fertility. Tomar *et al.* (1992) observed similar trend and reported that, seed and stover yields were increased significantly with application of N, P and K upto 80, 40 and 40 kg ha^{-1} due to increase in growth and yield attributes. Oil yield was significantly higher under the above NPK dosage, while oil content in seed was higher under no fertilization. Khan and Agarwal (1985) and Dubey and Khan (1993) also noticed this phenomenon.

With regard to the second factor, treatments with organic manure were better than the control, proving its higher and consistent nutrient releasing ability. Similar trend was observed in the case of biofertilizer and/or organic spray (Alagawadi, 1998).

The interaction of fertilizer levels and manurial forms showed positive effect on the yield attributes. Though the seed yield and biological yield were maximum in the treatment with 100% RDF alone, combination of fertilizer levels and manurial forms produced comparable results. Organic manures have been recorded to enhance the efficiency and reduce the requirement of chemical fertilizers. The seed yield of

sunflower was significantly high with vermicompost at 10 t ha^{-1} compared with other sources (Dayal and Agarwal, 1998; Bobde *et al.*, 1998) Similar effect on straw yield and biological yield was also noted [Fig.5.2.2 (a & b)].

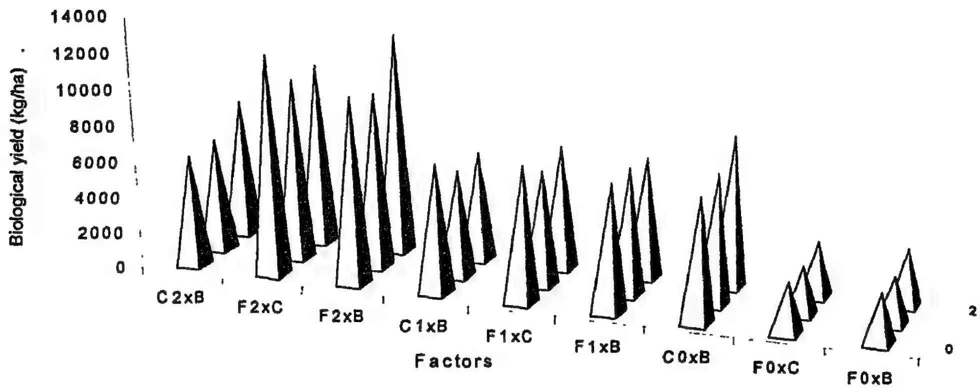


Fig. 5.2.2(a) Effect of interaction of fertilizer levels, manurial forms and biofertilizers and/or organic spray on the biological yield of mustard crop (kg ha^{-1}) during 1997-98

Interaction of fertilizer and biofertilizer and/or organic spray showed favourable effect on the yield contributing factors during both the years. This is apparently an evidence of synergy between the two forms of nutrient carriers. Cropping systems with higher intensities of resource utilization require nutrient management with such dimensions, for their sustainablity. According to Ramamurthy and Shivashankar, 1996 during *rabi* season, maximum uptake of NPK nutrients was recorded, where mustard crop received recommended dose (80:40:20) of fertilizers, preceded by the treatment received through inorganic source applied to *kharif* season crop (i.e., soybean). This could be due to the residual effect of nutrients available through organic source and fixation of atmospheric N by soybean. It is clear that for sustaining the productivity in soybean - mustard double cropping sequence, part of the total nutrients should be applied through organic source to preceding crop (i.e., soybean). Organic manure helped in enrichment of the soil with nutrients and fixation of atmospheric N by preceding crop (i.e., soybean) significantly. This phenomenon was observed by Sharma *et al.* in 1999.

The oil yield increased with integration of organic or biological sources of nutrients with lower doses of fertilizers. Sardana and Sidhu in 1994 observed negative

correlation between N application and oil content of seeds. Inoculation of single and dual culture coupled with lower fertilizer doses increased the oil content of mustard seeds. Sardana and Sidhu (1994) opined that P application increased the oil yield with or without green manure application. Promising trend in interaction between manurial forms and biofertilizer and/or organic spray was also observed.

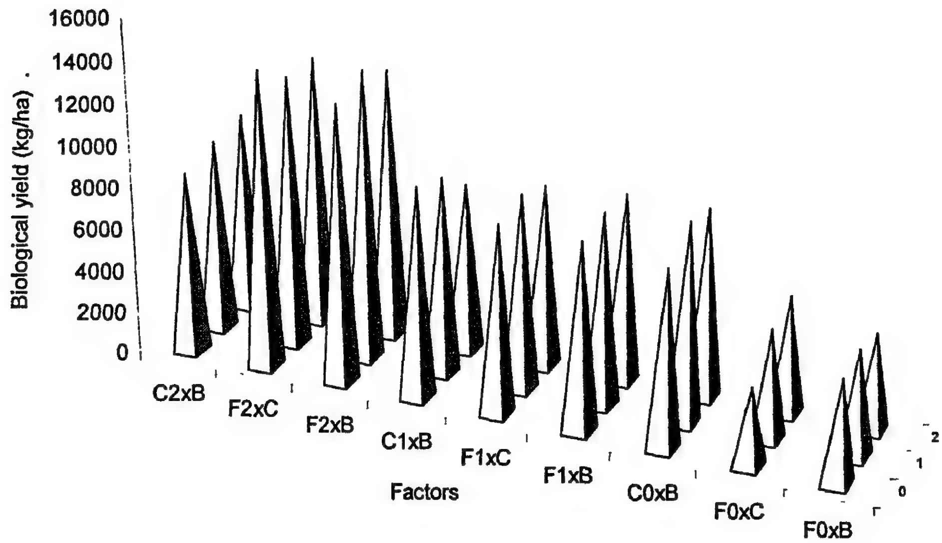


Fig. 5.2.2(b) Effect of interaction of fertilizer levels, manurial forms and biofertilizers and/or organic spray on the biological yield of mustard crop (kg ha^{-1}) during 1998-99

5.2.3 Post cropping soil physico-chemical status

The soil analysis at post harvest stage of mustard revealed the influence of fertilizer on the physico-chemical properties of soil in the INM package. Treatment plots analysed low EC_{25}. This may be attributed to the neutralizing effect of inorganic fertilizers.

Manurial forms significantly increased the organic carbon [Fig, 5.2.3(a & b)] and available potassium. The soil microbial activity may have encouraged mineralization and nutrient availability in the rhizosphere, which has been documented by Kale *et al.* in 1990. At the same time the nutrient retention has increased, unlike in soils with very low organic carbon and disproportional nutrient status.

Though the biofertilizer and/or organic spray did not produce significant effect, the organic carbon status and available potassium were higher in either of the treatments

PSB+CU or PSB+Rhz. This could be explained by the nutrient balancing ability of phosphorus in soil.

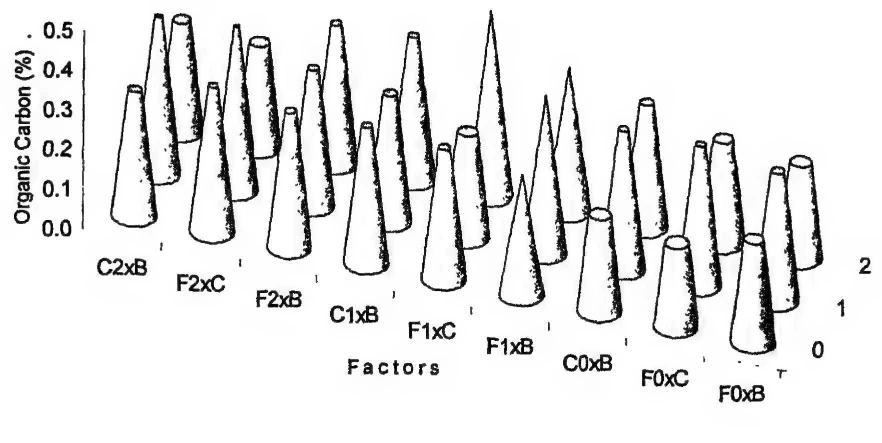


Fig. 5.2.3(a) Effect of interaction of fertilizer levels, manurial forms and biofertilizers and/or organic spray in mustard cropping on the organic carbon status of soil during 1997-98

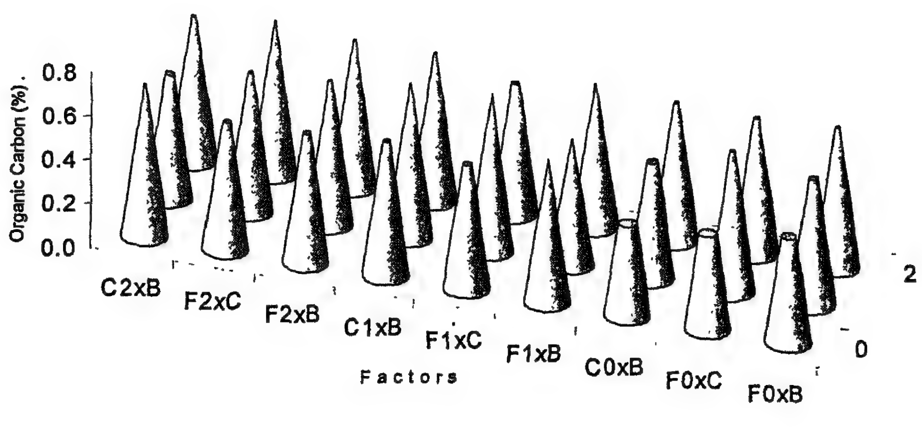


Fig. 5.2.3(b) Effect of interaction of fertilizer levels, manurial forms and biofertilizers and/or organic spray in mustard cropping on the organic carbon status of soil during 1998-99

Interaction of fertilizer with manurial forms showed that their combined effect enhanced the soil fertility build up as reflected by the organic carbon status of the soil and this finding is in conformity with Hegde (1998). Further, the available phosphorus

and potassium in the residual soil revealed that the integration of organic manures and chemical fertilizers was beneficial in maintaining the soil fertility and productivity of the cropping system

The interactive effect of fertilizer with biofertilizer showed that $^{1}/_{3}{}^{rd}$ dose of fertilizer in combination with PSB+Azsp registered significantly lower value of EC_{25} and higher values of organic carbon. Interaction of fertilizer with PSB+CU and PSB+Azsp recorded comparable availability of phosphorus and potassium as in the treatments with fertilizer alone.

Combination of manurial forms and biofertilizer and/or organic spray influenced the physico-chemical status of the soil. The organic carbon, available phosphorus and available potassium analysed in such combinations showed highest values. This was noticed by Mathan *et al.* (1994) in pigeonpea cropping system.

Studies on appropriate combinations of bulky organic manures and biofertilizers with inorganic fertilizers by Palled (1998) revealed similar conclusions to achieve sustainability in crop production.

5.3 Experiment 1: (Soybean – Mustard – Fodder cowpea system) Crop component 3: Fodder cowpea

5.3.1 Dry matter accumulation

At most of the stages fertilizer influenced the dry matter accumulation of fodder cowpea. Though the treatment 100% RDF registered the highest values at most of the stages, 33% RDF showed marked response and statistical comparability at several stages (Fig. 5.3.1). Sawarkar and Goydani (1996) suggested that the recommended dose of fertilizers (RDF) may be reduced.

Higher values of dry matter accumulation were observed at early stages in FC+PM and at later stages in FC+VC treatment combinations. Both these combinations of manures are suitable nutrient carriers. Bano *et al.* (1987) and Kale *et al.* (1990) have stated the benefits of vermicompost. Madhavi, *et al.* (1995) observed that increasing levels of NPK fertilizers, poultry manure and their interaction significantly increased the dry matter production.

Biofertilizer and/or organic spray significantly influenced the dry weight at one stage during both the years. However, the highest figures at each successive stage were produced by either of the treatments, *viz*., PSB+CU or PSB+Rhz. This may be caused by the catalytic and growth promoting properties of biological cultures and cow's urine.

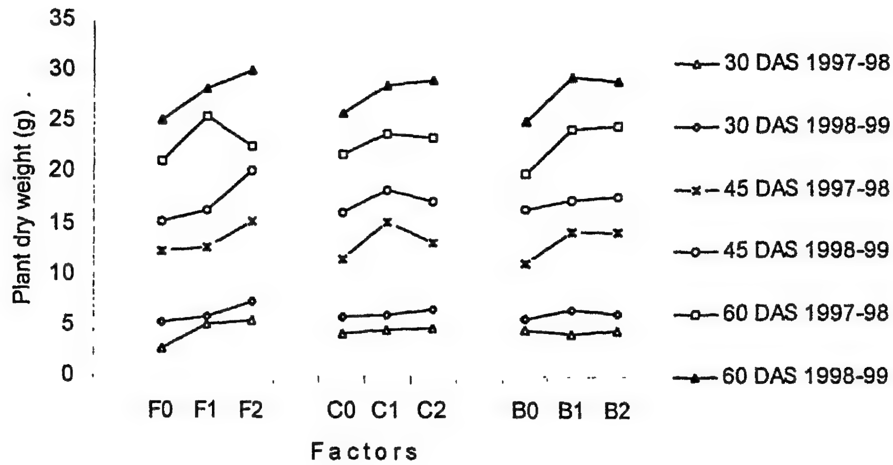


Fig. 5.3.1 **Effect of INM on dry weight of fodder cowpea (g/plant) during 1997-98 and 1998-99**

The interaction between fertilizer levels and manurial forms was positive throughout the cropping period during both the years. The compatibility of organic and inorganic forms of nutrient carriers for a balanced nutrient management is inevitable for increased growth. This has been emphasized amply by other researchers [Pawar (1997) and Patil (1998)].

Interaction of fertilizer and/or biofertilizer was noticeably significant as the treatment combination involving both levels of fertilizers with PSB+CU which showed remarkably high figures of dry weight which is clearly pointing to the fact that the biofertilizer component is a viable alternative for partial replacement of inorganic fertilizers. Research done by Maheshwari (1974) and Sawarkar and Goydani (1996) are in conformity.

Interaction effects of manurial forms and biofertilizer and/or organic spray showed significance, similar to the previous combination.

5.3.2 Nodulation pattern

The nodulation pattern exhibited by the fodder cowpea in the cropping system was higher in plots with no or lower levels of nitrogen application (Fig. 5.3.2). This was similar to reports of Alagawadi (1998).

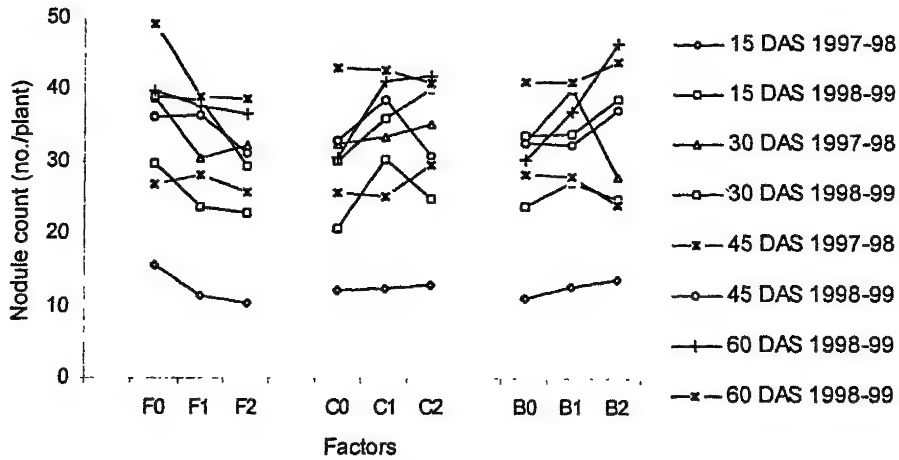


Fig. 5.3.2 **Effect of INM on nodulation of fodder cowpea (number /plant)**

The manurial forms used in the present trial as such did not show any significant difference. However, on critical perusal of the data it is obvious that the plots treated with either forms of the manure registered higher nodule count. This may be attributed to the fact that the organic manure has, among other properties, the capacity to improve the condition of the soil, enhancing the root development. Hiremath and Kalappanavar (1998) have observed this phenomenon.

There was no significant difference in the nodule count due to the factor biofertilizer and/or organic spray, though higher values were recorded in treated plots. The reason underlying this is the presence of native population of *Rhizobium phaseolii* in sufficient number. Dual inoculation with VAM and *Rhizobium* further significantly increased legume growth, nodulation (Baruah *et al.*, 1995).

The data on nodulation as influenced by interaction of the above three factors show similar trends, and is in line with the report of Lopes *et al.* (1996).

5.3.3 Yield (fresh weight and dry weight basis) and nutritional status of fodder

All treatments were significantly superior to the control. Treatment with $^1/_3{}^{rd}$ dose of fertilizer was comparable but marginally better than the full dose in both the years. The dry matter: fresh weight ratio in all treatments was lower in the 2nd year of cropping system than in the 1st year. This is perhaps due to the higher rainfall recorded in the 2nd year, resulting in excessive moisture content in the herbage. The carbohydrate content was maximum in the treatment with lower fertilizer rate, whereas the higher dose was responsible for increased protein content in the forage. This is due to the higher dose of nitrogenous fertilizer, administered to the crop through split application, and the latter dose has been assimilated usefully for improving the quality of the crop.

The manurial forms significantly influenced the fodder yield in both the years (Fig.5.3.3). Treatment FC+VC proved to be better in the 1st year but FC+PM was superior both in terms of the quantitative and qualitative parameters, *viz.*, yield, carbohydrate and protein content in the 2nd year. The importance of organic forms of nutrition is essential, for the production of forage crops with balanced nutritional quality with least residues of harmful substances for the livestock. Bhatia and Shukla (1982) and Bano *et al.* (1987) reported similar results.

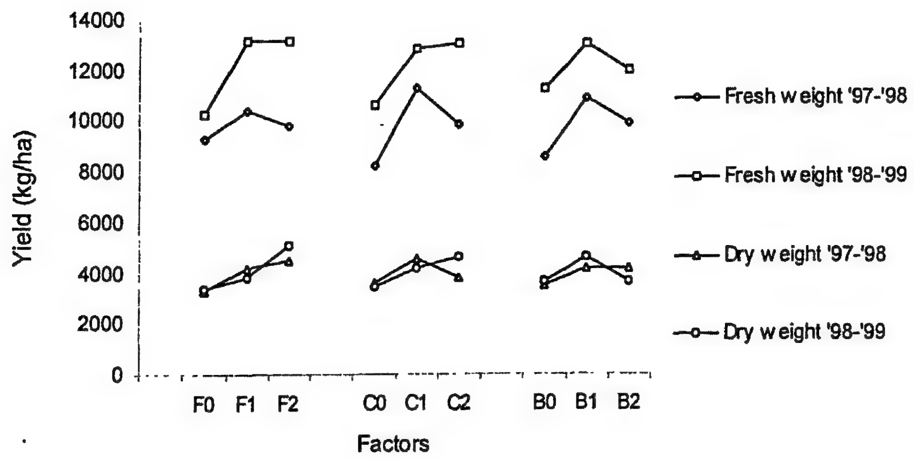


Fig. 5.3.3 **Yield of fodder cowpea (kg ha^{-1}) as influenced by INM during 1997-98 and 1998-99**

The PSB+CU component exhibited its influence at 60 DAS in the 1st year and the values at all stages in general were higher in either of the treatments PSB+CU or

PSB+Rhz. The crop has expressed this by yielding more of protein and carbohydrates. This may be due to the catalysing effect of bio-cultures in combination with organic spray. Patil *et al.* (1992) observed that the biofertilizer Azospirillum helped not only in increasing the green-forage production but also had more favourable effect on dry-matter and crude protein yields.

Positive effects were noticed in the crop quality as a result of interactive behaviour of the two important sources of nutrients. The interaction between organic and inorganic nutrient carriers was also reported by Gangwar and Singh (1992) who observed that significantly higher green-fodder, dry-matter and crude protein yields were recorded with 100% recommended inorganic fertilizer, followed by 6 tonnes of farmyard manure ha^{-1} + 50% inorganic fertilizer.

The interactions between organic and biological forms was also evident in both fresh weight and dry weight bases, and similar findings with vegetable soybean performed best with pig manure compost with micro organism mixture containing nitrogen-fixers, PSB, VAM etc. as reported by Hsieh and Hsu (1995).

The interactions between all nutrient sources, *viz.*, organic, inorganic and biological showed significant increase on herbage yield (fresh weight and dry weight basis) as well as the quality. The reason behind this could be their complimentary and synergistic effect on vegetative growth. Subbian and Palaniappan (1992) have reported the beneficial effect in terms of yield increase of upto 30.9%.

5.3.4 Post-cropping soil status

The post-cropping soil sample from the fodder cowpea analysed a marked reduction of EC_{25} (Fig. 5.3.4) and increased values of organic matter content (Fig. 5.3.5), available phosphorus and potassium due to each of the individual factors and their interactive effects. Agboola *et al.* (1975) and Newaj and Yadav (1994) reported similar trend at post-harvest stage. This kind of beneficial reaction within the rhizosphere is of paramount importance for building up the soil fertility and productivity.

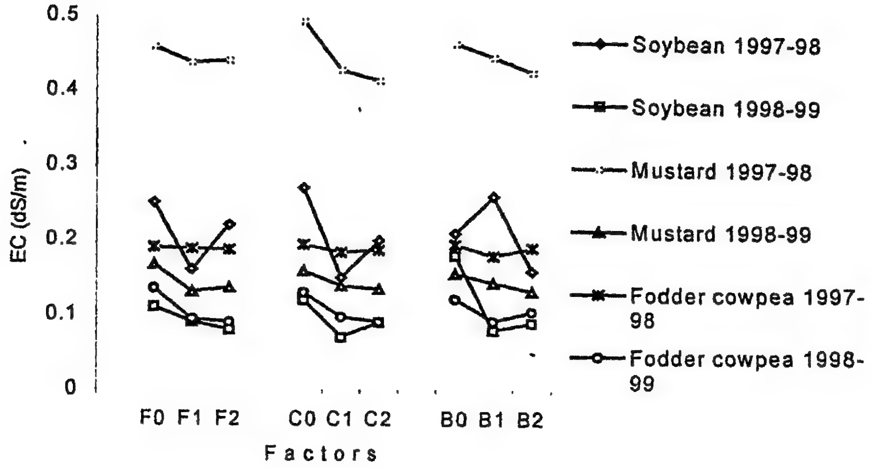


Fig. 5.3.4 **Effect of INM in Soybean-Mustard-Fodder cowpea system on the EC_{25} (dS m^{-1}) in soil during 1997-98 and 1998-99**

Itnal (1998) stated that the combined use of several forms of nutrient carriers favours improvement of soil physical, chemical and biological conditions. Further this also helps in raising mineralization efficiency and nutrient recovery from organic resource (Kale *et al.*, 1990).

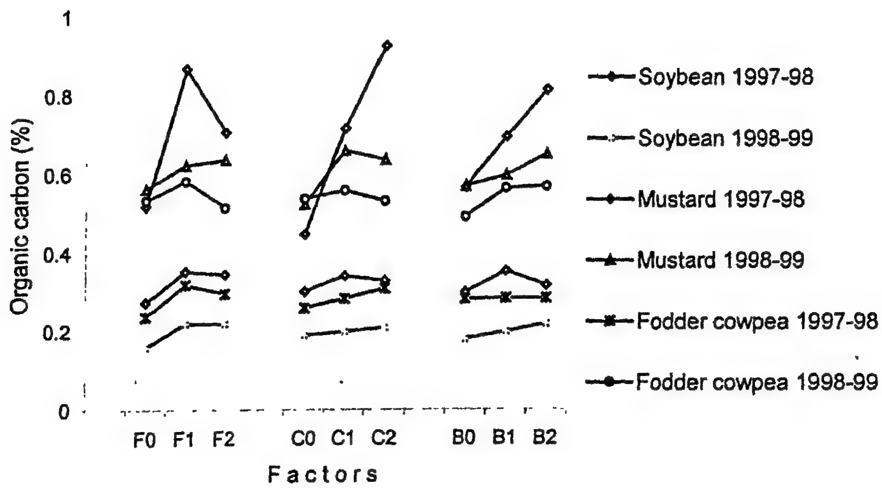


Fig. 5.3.5 **Effect of INM in Soybean-Mustard-Fodder cowpea system on the percentage organic carbon in soil during 1997-98 and 1998-99**

5.4 Experiment 2: (Blackgram – Wheat – Greengram system)
Crop component 1: Blackgram

5.4.1 Dry matter accumulation

The dry weight of blackgàm registered comparable figures in treatments with full dose and 1/3rd dose during most of the cropping period (Fig.5.4.1). This can be attributed to the high fertilizer use efficiency with the INM package in the cropping system. The feasibility of reduced dosage of fertilizer application has been purported by Dubey (1992).

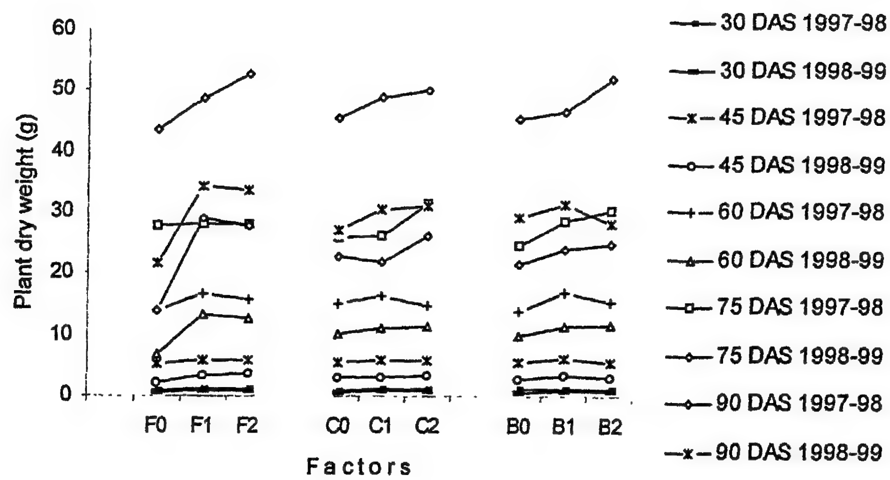


Fig 5.4.1 Effect of INM on the dry weight of blackgram (g/plant) during 1997-98 and 1998-99

The manurial forms and biofertilizer and/or organic spray were found to be effective in maintaining higher dry weight. The interaction between these factors indicated the importance of integration of various sources of nutrients for a sustainable agronomic package for the legume based cropping system. Several researchers have supported this practice and suggested it to be eco-friendly. Moharram *et al.* (1999) found that Bradyrhizobium + compost significantly increased, plant dry weight, N yield and N fixation compared with uninoculated plants.

5.4.2 Nodulation pattern

Nodulation in the Blackgram crop component was significantly influenced by the $^{1}/_{3}$rd dose of fertilizer at the later stages. Observations indicate that the lower doses of fertilizer were more efficient in nitrogen fixation (Table 4.13). Vara *et al.* in 1998

observed that the number of nodules decreased with increasing level of N application. This might be due to the reason that at higher levels of N, the plant receives its N from N applied to the soil and hence bacteria do not fix atmospheric N, as they become inactive in the presence of sufficient soil N.

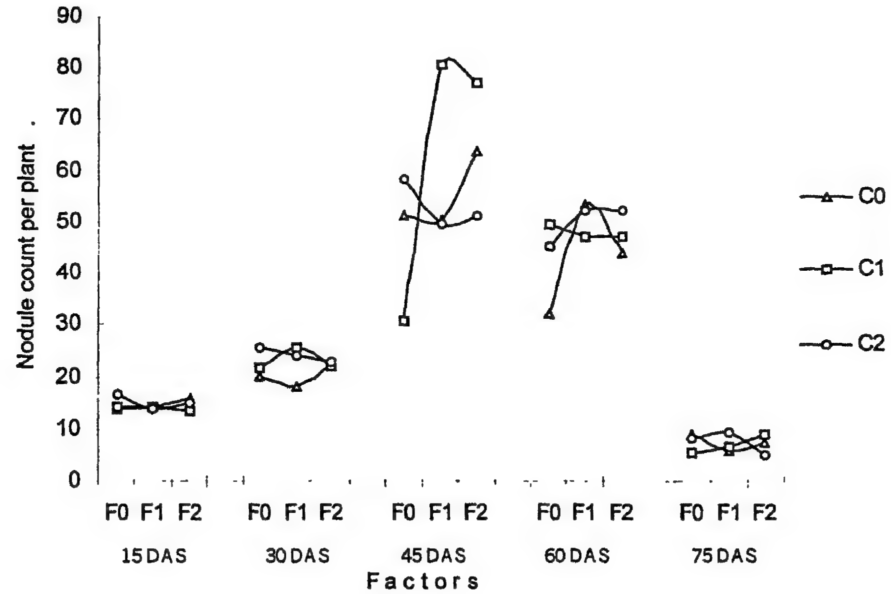


Fig 5.4.2(a) Effect of interaction of fertilizer levels and manurial forms on nodule count of blackgram (number/plant) at successive stages during 1997-98

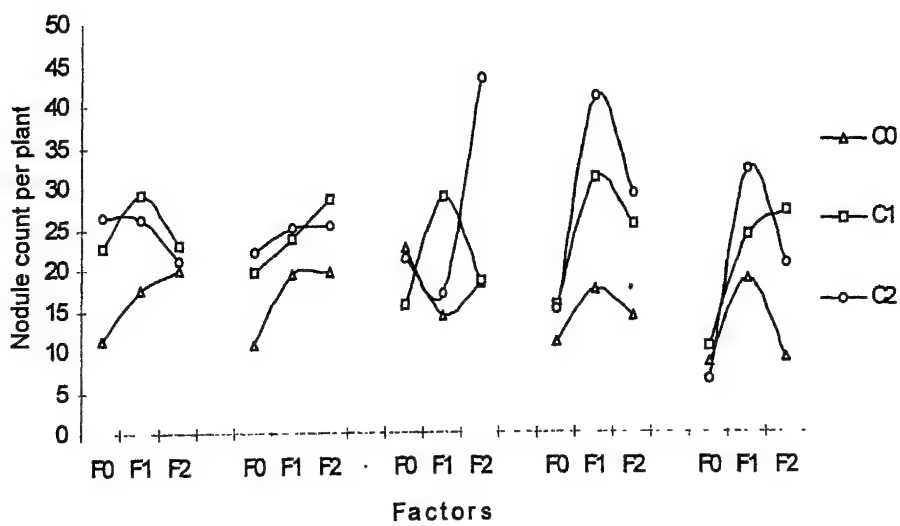


Fig 5.4.2(b) Effect of interaction of fertilizer levels and manurial forms on nodule count of blackgram (number/plant) at successive stages during 1998-99

Nodulation pattern was comparable in all treatments. This could be due to the sufficient native and inoculated rhizobium population species and their efficiency. The trend of higher nodulation pattern with the usage of organic manure further proves their synergistic effects in soil. Figures. 5.4.2 (a & b) show the increase in nodule count at successive stages influenced by the interaction between fertilizer levels and manurial forms. The findings are in line with that of Nagaraju *et al.* (1995) who reported similar interactive effect, expressed in terms of nodule dry weight. The peak nodulation was found between 45 and 60 DAS.

5.4.3 Yield attributes

Similar trend was observed at the grain filling stage and at harvest. The pod count per plant was influenced by both the fertilizer dosages in a comparable manner and the values were higher in both the manurial forms than in the control (Fig. 5.4.3). The test weight was maximum in the PSB+CU combination of biofertilizer and/or organic spray and in FC+PM combination of manures during both the years. Tomar *et al.* (1993) observed that the application of phosphate-solubilizing bacteria significantly increased the seed yield over the control from 9.5 in the 1st year to 22.5% in the 2nd year. Influence on the pods/plant and seed index was also evident. Mahanta and Borah (1998) observed that poultry manure were most effective in increasing the yield of blackgram.

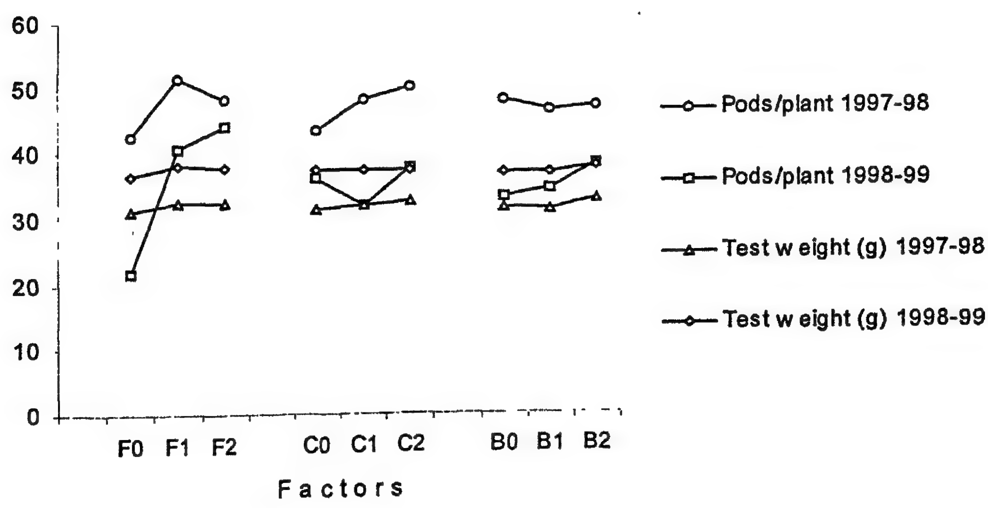


Fig. 5.4.3 **Effect of INM on the yield attributes of blackgram during 1997-98 and 1998-99**

The yield parameters responded well to the combination of these factors. The seed yield also exhibited similar trend in terms of response to the interactions between

the factors, proving further that the INM package is the most suitable agronomic technology for legume based cropping system. The work done by Latha and Subramanian (1991) and Dwivedi *et al.* (1993) is in agreement with the present findings.

5.4.3 Post-cropping status of soil

Most of the physico-chemical parameters showed significant effects (Fig. 5.4.4) of individual factors as well as their positive interaction.

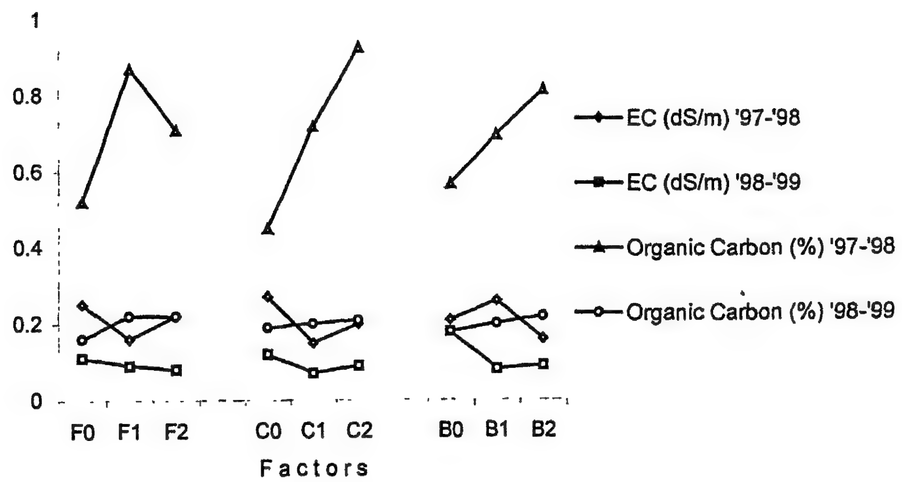


Fig. 5.4.4 **Effect of INM in blackgram cropping on the EC_{25} and organic carbon in soil during 1997-98 and 1998-99**

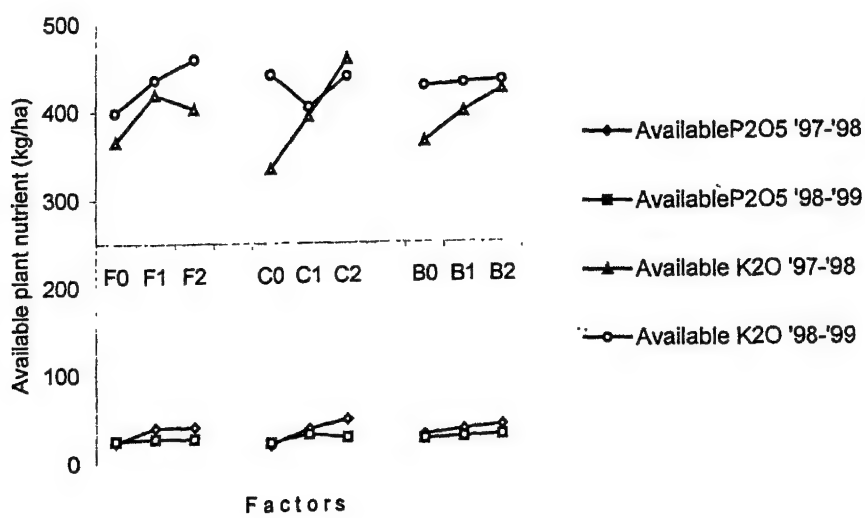


Fig. 5.4.5 **Effect of INM in blackgram cropping on the available P_2O_5 and K_2O (kg ha^{-1}) in soil during 1997-98 and 1998-99**

The status of available phosphorus and potassium (Fig. 5.4.5) were high in both the years in the interaction combinations of 100% RDF with FC+PM and with PSB+CU. The integration of the various forms of nutrient carriers has been proved to create a balancing effect among the soil microflora, physical conditions and the chemical constituents. Hegde in 1998 noticed that integration of fertilizers and organic sources improves the organic carbon status of soil, which helps in long-term sustainability. These findings were corrobrated by Prabhakar and Patil (1998) who observed that combined application of inorganics and organics improved soil physical condition and eventually helped sugarcane crop. The percentage organic carbon and available nutrient status of P_2O_5 and K_2O also showed increase due to the integration.

5.5 Experiment 2: (Blackgram – Wheat – Greengram system) Crop component 2: Wheat

5.5.1 Dry matter acumulation

The full dose of fertilizer was superior to $^{1}/_{3}{}^{rd}$ dose, which in turn was significantly superior to the 0 level dosage. Ranwa and Singh (1999) reported similar findings. At 75, 90 and 105 DAS during the 1^{st} year there was comparability between the 1^{st} two levels. The reasonably satisfactory performance of the $^{1}/_{3}{}^{rd}$ dose may be attributed to the complimentary role of the other components, *viz.*, organic manures and

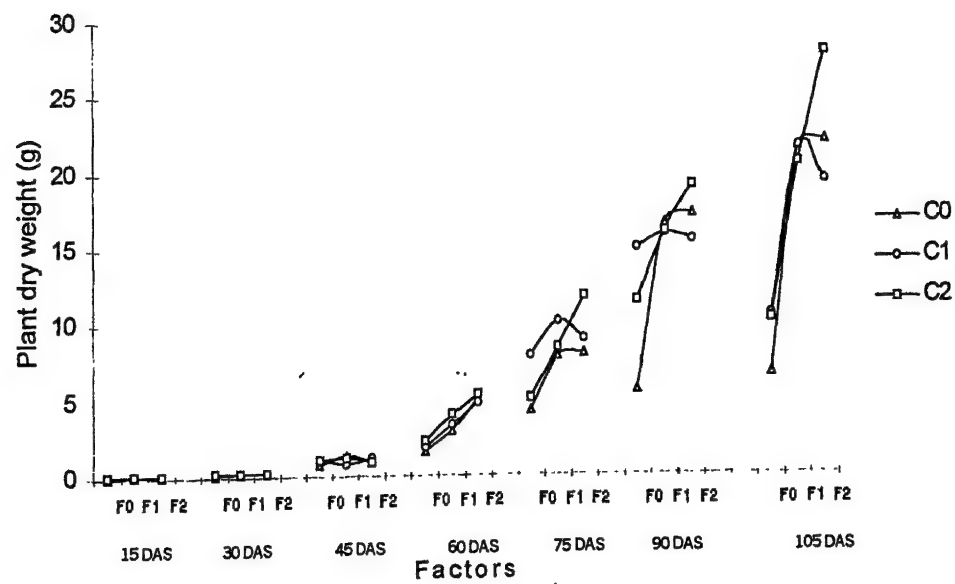


Fig 5.5.1(a) **Effect of interaction of fertilizer levels and manurial forms on dry weight of wheat (g/plant) at successive stages during 1997-98**

biofertilizer and/or organic spray in the INM package, and the residual fertility build-up because of the preceding legume crop of blackgram. Organic manures have been recorded to enhance the efficiency and reduce the requirement of chemical fertilizers (Dayal and Agarwal, 1998). Daterao and Lakhdive (1992) opined that preceding legume treatment showed better performance in succeeding wheat.

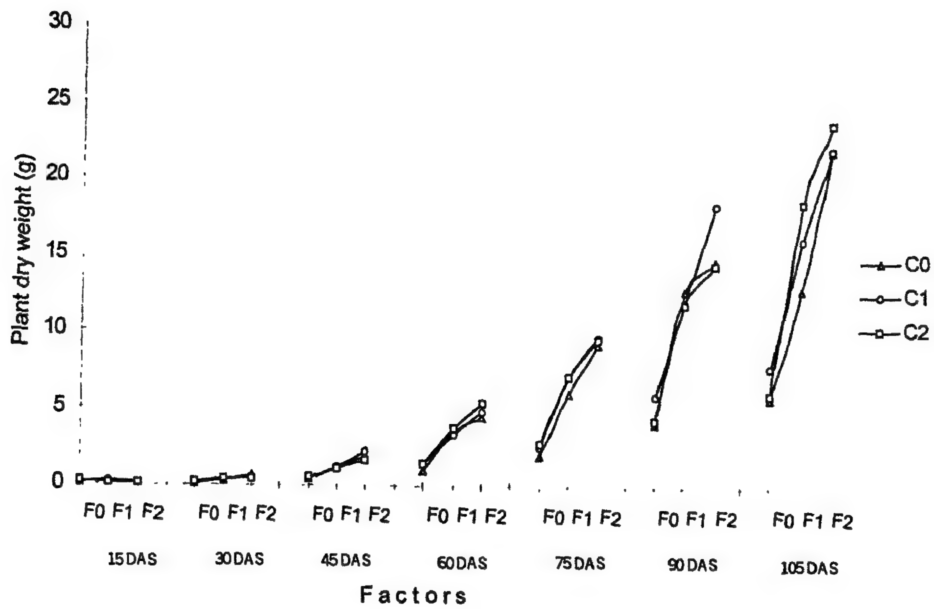


Fig 5.5.1(b) **Effect of interaction of fertilizer levels and manurial forms on dry weight of wheat (g/plant) at successive stages during 1998-99**

The treatments with manurial forms and biofertilizer and/or organic spray individually apparently did not perform significantly throughout the cropping period. Nevertheless, their interaction effect with the fertilizer factor and with each other exhibited positive influence on the dry matter accumulation [Fig. 5.5.1 (a & b)]. This can be substantiated by the findings of George, *et al.* (1998). They reported that *Azospirillum* alone, elicited significant increase in yield over the absolute control. Small dose of mineral N enhanced the efficiency of *Azospirillum* inoculation. Raghuwanshi and Umat (1994) observed that the response of wheat was highest when 50% of NPK was applied as inorganic fertilizer and 50% N as FYM.

5.5.2 Yield parameters

The data presented in the Table 4.17 indicates that the yield parameters were influenced by fertilizer doses. The number of effective tillers per plant, grain yield and biological yield increased with the progressive increase in the fertilizer dosage. The full

dose of fertilizer was superior to the $^1/_3{}^{rd}$ dose, which in turn was significantly higher than the 0 RDF level. Morey and Bagde (1982) reported that among urd – wheat sequence gave maximum wheat yield.

Test weight values were higher in treatments with 100% RDF and 33% RDF in comparison to the control in both the years. The FC+PM combination of manurial form was responsible for maximum values of effective tiller per plant, test weight, grain yield and biological yield in both the years. Statistical parity between the two forms of manure, with regard to the last two parameters was noticed in the 2nd year.

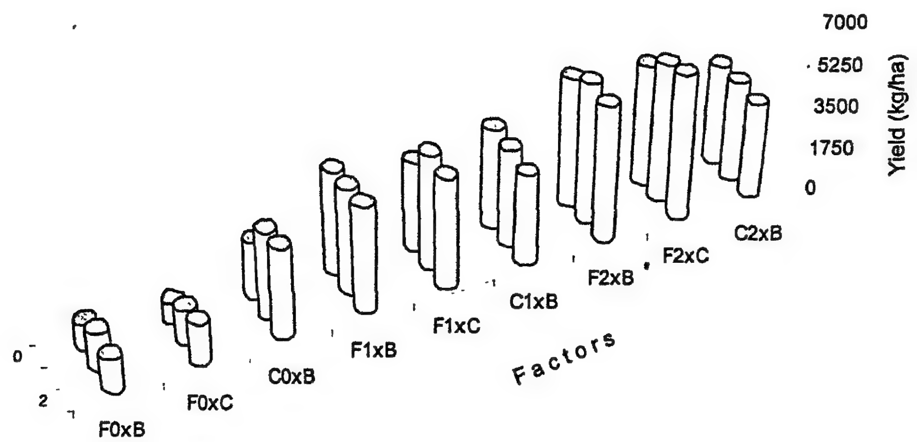


Fig. 5.5.2 (a) **Effect of INM on the yield of wheat in the legume based cropping system during 1997-98**

Thus, the potential of combination of poultry manure with farm compost seems to be promising for grain crop. Singh *et al.* (1998) noticed that the rice yield was higher with poultry manure alone than with mineral fertilizers alone, and poultry manure was much more effective than FYM. The wheat yield was greatest from the residual effects of poultry manure alone or with NPK. Combined application of inorganic and organic sources produced significantly higher yield attributes in wheat than application of individual source.

Interaction between these factors exhibited positive effects on the yield parameters during the experimental period [Fig. 5.5.2 (a & b)]. Kunnal (1998) suggested that application of vermicompost (2.5 t ha^{-1}) could substitute 25% RDF. Application of *Azospirillum* @ 10 kg ha^{-1} along with vermicompost (2.5 t ha^{-1}) could

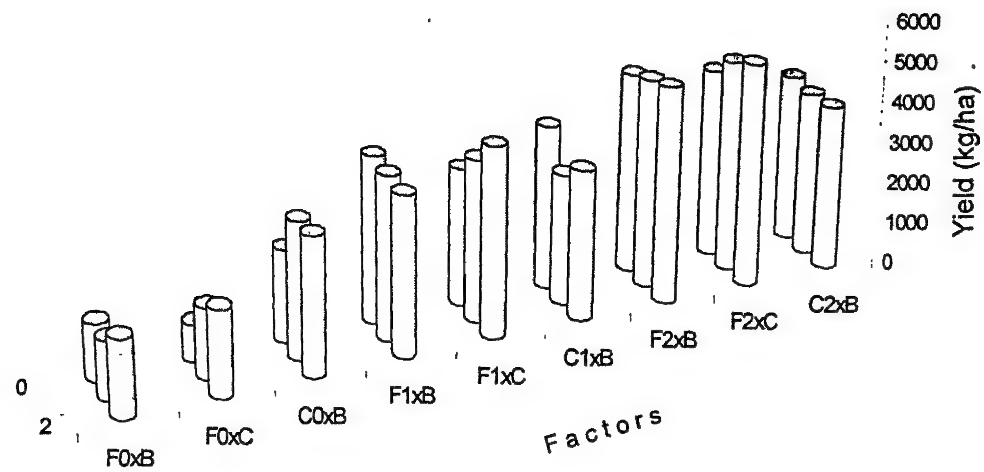


Fig. 5.5.2 (b) **Effect of INM on the yield of wheat in the legume based cropping system during 1998-99**

substitute 50%. This paves way for scientific integration of various forms of nutrient sources, which not only act as suppliers of nutrients, but also as ammenders of soil physico-chemical and biological conditions. Such an amalgamative approach is sustainable and profitable for building up cropping systems with least consequences of breakdowns.

5.5.3 Post-cropping soil status

The effect of wheat cropping under integrated nutrient management system on the physico-chemical properties of the soil was markedly significant. The treatment 100% or 33% RDF registered reasonably higher values of available potassium, available phosphorus and organic carbon.

The treatments with manurial forms recorded the least value of EC_{25} and higher figures of organic carbon (Fig. 5.5.3), available phosphorus and available potassium (Fig. 5.5.4), inferring that the organic forms of soil ammendments build up soil fertility. Kale *et al.* in 1990 brought forth that regular application of worm cast (vermicompost) to the fields improves the physico-chemical and biological properties of the soil. The worm casts supply the essential nutrients in the available form to the plants. The organic carbon in vermicompost releases the nutrients slowly and steadily into the system and enables the plants to absorb the available nutrients.

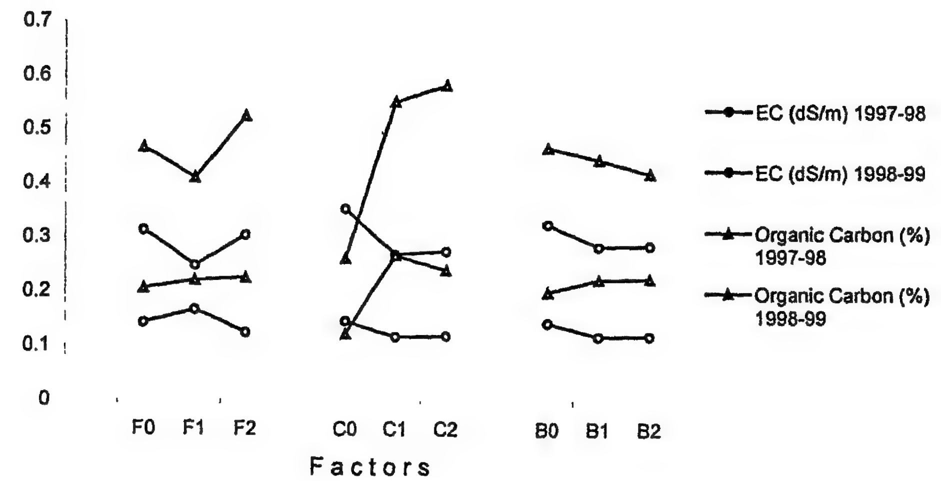


Fig. 5.5.3 **Effect of INM in wheat cropping on the EC_{25} and organic carbon status of soil during 1997-98 and 1998-99**

Lower values of EC_{25}, medium figures of available phosphorus and higher values of available potassium were noticed in the treatments with biofertilizer and/or organic spray and this indicates that these components may be included for sustaining the productive potential of the cropping system. Gopalkrishnan and Palaniappan (1992) observed that application of FYM resulted in medium available N and high available P as compared to no FYM treatment in soil. However, significant effect on the soil available K was not observed.

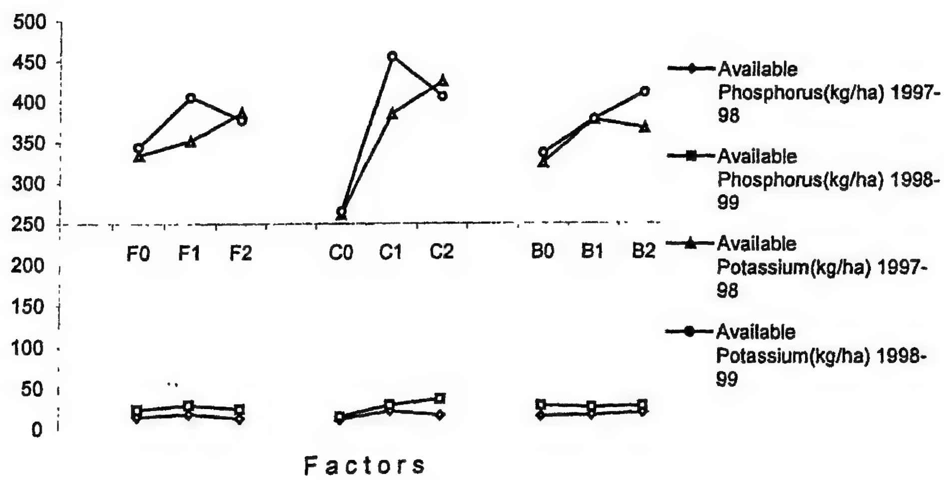


Fig. 5.5.4 **Effect of INM in wheat cropping on the available P_2O_5 and K_2O status of soil (kg ha^{-1}) during 1997-98 and 1998-99**

The statistical analysis of the interaction of these three factors on a bilateral basis showed that each of these interactive phenomena have a contributory effect on the

overall balancing and replenishing of soil nutrient holding and supplying status. The study confirms the results. Nitrogen requirement and growth and development of crops in a rotation are expected to be influenced by the preceding crops, depending upon their nature. Inclusion of legumes in rotation improves soil structure, enriches soil nitrogen and results in higher productivity of succeeding crops (Sharma *et al.*, 1985). The combined application of chemical fertilizers with organic manures has been favoured for improving the soil physical, chemical and biological conditions. This also helps in raising mineralization efficiency and nutrient recovery from organic resource. Organic manures have been generally valued as source of the primary nutrients, but they are a potential source of micronutrients also (Itnal, 1998).

5.6 Experiment 2: (Blackgram – Wheat – Greengram system)

Crop component 3: Greengram

5.6.1 Dry matter accumulation

Significantly higher values of plant dry weight due to the factors, *viz.*, fertilizer levels and manurial forms was noted practically during the entire cropping cycle (Fig.5.6.1). This is definitely due to the availability of essential nutrients and also the favourable conditions prevailing, particularly during the critical growth phases, as a result of the addition of organic matter combined with the inorganic, mineral forms of nutrients.

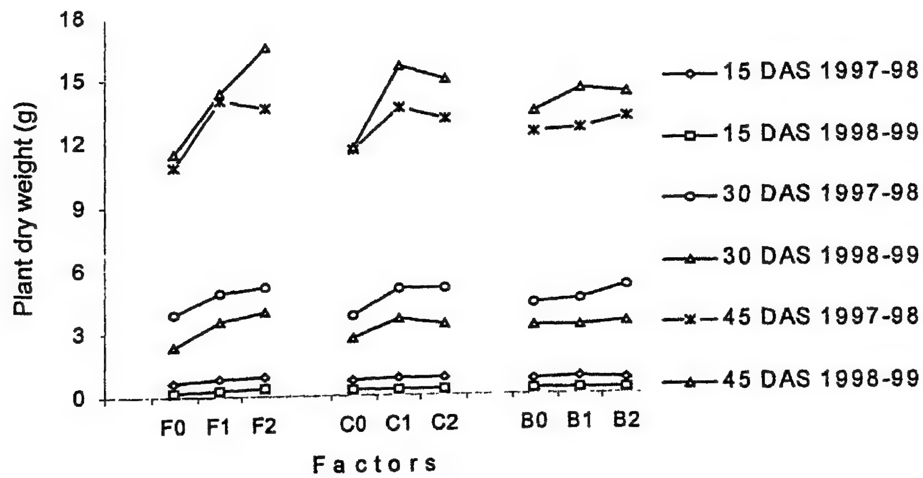


Fig. 5.6.1 **Effect of INM on the dry weight of greengram (g/plant) during 1997-98 and 1998-99.**

The biological forms of nutrient carriers, particularly when administered in combination with the organic spray also registered higher values throughout the crop period. Subbian and Palaniappan (1992) have observed this.

The interaction between the three factors, *viz.*, fertilizer levels, manurial forms and biofertilizer and/or organic spray was noted to be positive for dry weight in comparison to zero level combinations. This indicated that the legume species in a cropping system with INM has a potential to produce larger dry matter. This could meet the increasing demand for food, fodder and bio-matter. Crop residues can also be recycled into manure by composting. These findings further corroborate the results reported by Chinnusamy and Rangasamy (1997) and Chittapur (1998).

5.6.2 Nodulation pattern

The intensity of nodulation was mostly highest in the treatment without fertilizer followed by the treatments with lower dose of fertilizer, i.e., 33% RDF. This is perhaps because lower nitrogen levels promote the nodualtion in roots of plants so as to check nitrogen deficiency faced by the plant system. This can be substantiated by the findings of Ardeshna, et al. (1993), Alagawadi (1998) and Vara *et al.* (1998).

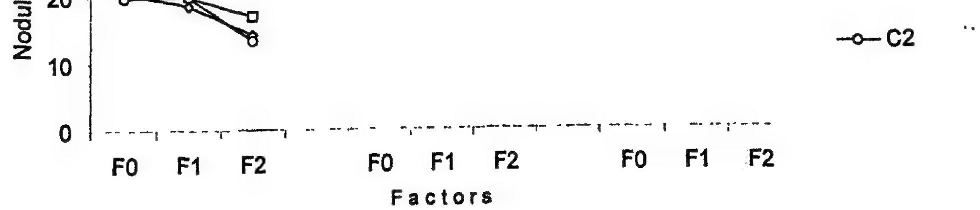


Fig 5.6.2(a) **Effect of interaction of fertilizer levels and manurial forms on nodule count of greengram (number/plant) at successive stages during 1997-98**

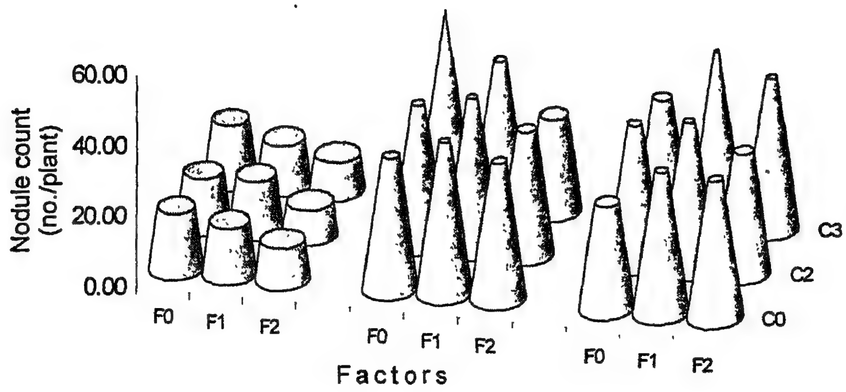


Fig 5.6.2(b) **Effect of interaction of fertilizer levels and manurial forms on nodule count of greengram (number/plant) at successive stages during 1998-99**

Though manurial forms and biofertilizer and/or organic spray application did not produce significant effects on nodulation, the higher counts of nodule per plant was observed in either of the treatment combinations containing these factors [Fig. 5.6.2 (a & b)]. This perhaps is due to the beneficial effects of dual inoculation with PSB and *Rhizobium*. Baruah *et al.* (1995) observed similar phenomenon.

The combined effect of lower doses of inorganic fertilizers, organic sources of nutrients and biofertilizers produced a positve interaction on nodulation. A microenvironment congenial for the activity of PSB and *Rhizobium* could be the reason for this phenomenon. Singh and Yadav (1992) reported similar effects.

5.6.3 Yield attributes

All the three factors, *viz.*, fertilizer levels, manurial forms and biofertilizer and/or organic spray registered higher values of the parameters of yield, *viz.*, pods/plant, seeds/pod, test weight (Fig. 5.6.3), seed yield and biological yield (Fig. 5.6.4). The fertilizer factor recorded maximum values due to the treatment 100% RDF or 33% RDF. Similarly, the manurial factor was responsible due to the treatment FC+PM or FC+VC combination and the biofertilizer and/or organic spray factor produced

increased values in the treatment PSB+CU or PSB+Rhz combination. The residual fertility build up over the period of six seasons may have contributed to the improved performance in plots receiving lower doses of inorganic fertilizers. This may be ascribed to the growth promoting properties of these factors, which has been observed by Sarmah *et al.*. (1992), Maheshwari (1974) and Kale (1993).

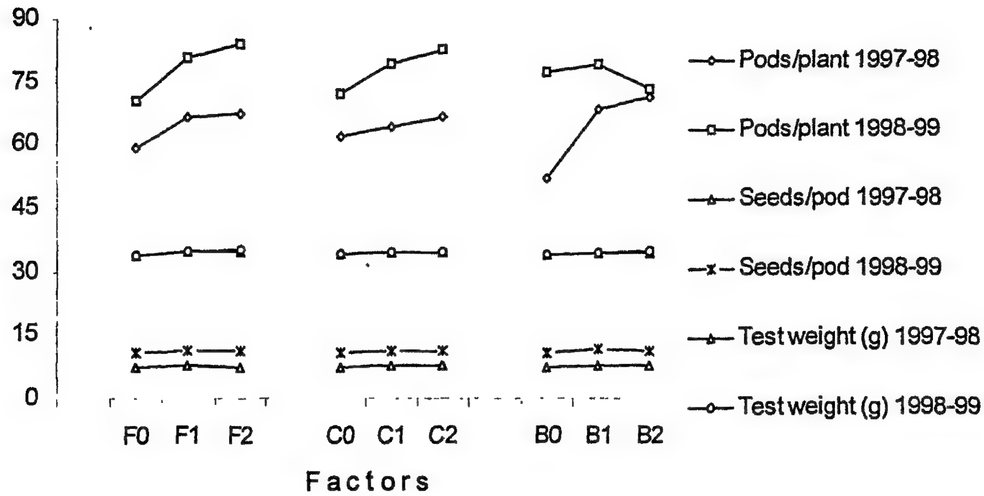


Fig. 5.6.3 **Effect of INM on the yield attributes of gsreengram crop in the system during 1997-98 and 1998-99**

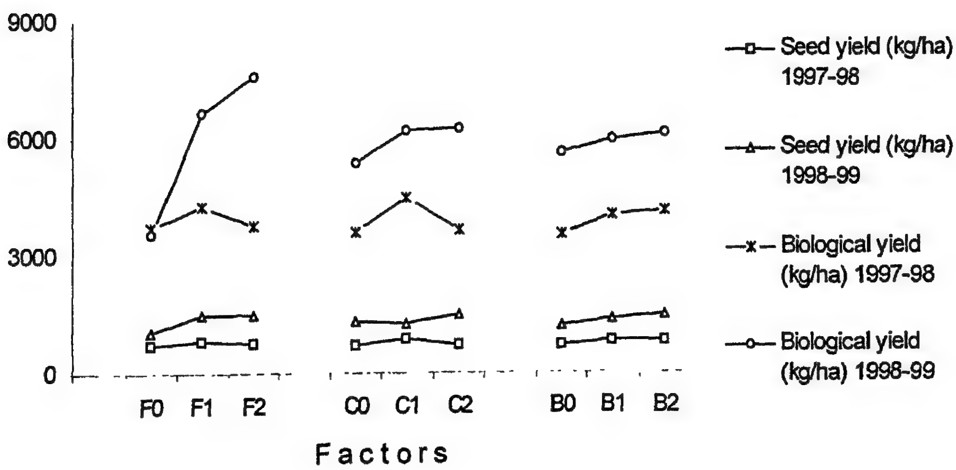


Fig. 5.6.4 **Effect of INM on the economical and biological yield of greengram crop in the system during 1997-98 and 1998-99**

Madhavi *et al.* (1995) and Nambiar and Abrol (1992) corroborated the findings with regard to interaction between these three factors on bilateral basis, which showed that there was a definite positive relationship that existed between them. The complimentary effect was beneficial in making the source to sink translocation function

at its optimal peak. This resultant effect can be assumed as sustainable in terms of fulfilling the cultivators' objective of maximising productivity in the cropping system.

5.6.4 Post-cropping soil status

The positive effect of greengram cropping under INM system on the physico-chemical properties of the soil was evident [Fig. 5.6.5 (a & b)]. The soil EC_{25} was remarkably lower in 100% or 33% RDF, FC+PM or FC+VC and PSB+Rhz or PSB+CU, among the three factors. These same treatments were responsible for the highest values of organic carbon, available phosphorus and potassium in both the years. Mahanta and Borah (1998) observed that poultry manure was most effective in increasing the yield of blackgram.

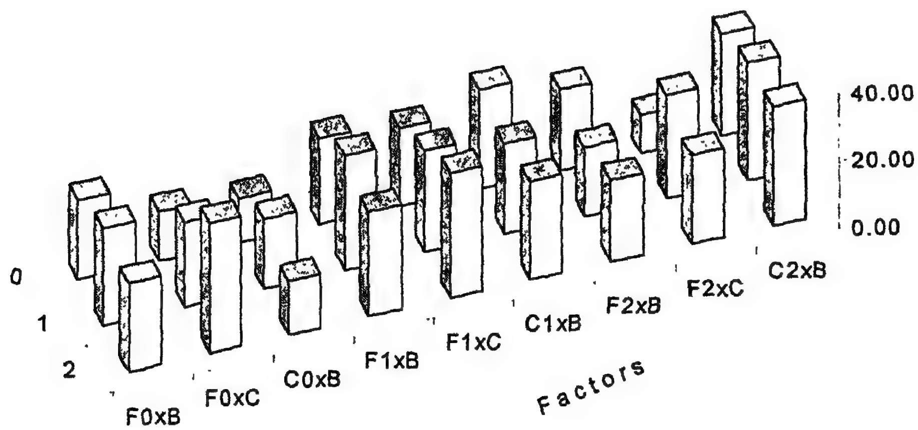


Fig. 5.6.5(a) **Effect of INM on available P_2O_5 (kg ha^{-1}) in the blackgram-wheat-greengram cropping system during 1997-98**

The treatments with 33% RDF showing higher values of organic carbon, available P_2O_5 and K_2O may be due to the reduced volatilization and leaching losses. Similar trend was maintained by the interactive effect of these factors, thereby proving the principle of synergy active in the rhizosphere.

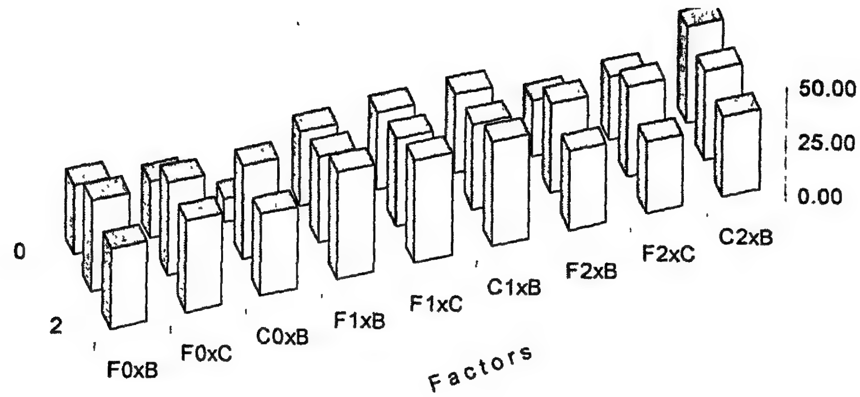


Fig. 5.6.5(b) **Effect of INM on available P_2O_5 (kg ha^{-1}) in the blackgram-wheat-greengram cropping system during 1998-99**

Increase in organic carbon content with integrated nutrient supply was mainly due to addition of organic matter (Patnaik *et al.*, 1989). Dayal and Agarwal (1998) concluded that this might be due to the improvement in physical, chemical and biological properties of soil by addition of organic manures. The interaction effect between organic sources and fertilizer levels was also significant.

SUMMARY

CHAPTER 6

SUMMARY

Soil health care is fundamental to sustainable intensified farming. The Integrated Intensive Farming System (IIFS) technology provides the pathway to achieving an evergreen revolution in agriculture. Biological diversity brings in yield and economic stability because of the potential for compensation among components of the system. The phenomenon of biological and economical bufferings in the farming systems is the emergent need of the present day agro-eco-technology with alternatives that depend more heavily on internal renewable resources available on the farm.

The Creator God has blessed every single ecological pocket with the most suitable species and also the adaptability to several of them. There is absolute harmony even in the farming and cropping systems, which, to a large extent are the handiwork of the crown of creation – mankind!

The adoption of appropriate crop rotations that include legumes is a means to maintain the soil fertility and productivity. The residual as well as current N transfer from legumes is important for N economy in cropping systems. Integration of inorganic plant nutrient sources with organic forms *viz.,* farm compost, vermicompost, poultry manure and biological forms produce synergy in a cropping system.

Considering the background and potential, an agronomic investigation entitled, "Studies on integrated nutrient management in legume based cropping system for the alluvial plains of Allahabad", was conducted at the Crop Research Farm, Department of Agronomy, Allahabad Agricultural Institute, Allahabad.

The crop growth as influenced by different INM packages was assessed. The extent of reduction in the use of chemical fertilizers in a cropping system was evaluated. Two practicable models of legume based cropping system were suggested. Sustainable package of INM involving biofertilizers and organic manures was propounded. The effect of INM packages on crop quality and soil fertility was studied.

The relevant findings of the research undertaken are summarized in this chapter.

6.1 Cropping system 1: (Soybean – Mustard – Fodder cowpea)

Crop component: Soybean

Increased dry matter accumulation was observed with full dose of fertilizer application at all growth stages of soybean. The dry matter accumulation was at the peak towards the crop maturity stage. The efficiency of native and applied plant nutrients was higher as observed by increased dry matter accumulation in soybean crop treated with phosphate solubilizing bacteria, *Rhizobium* and cow's urine. Application of biofertilizers in combination with poultry manure and farm compost showed synergistic effects on the growth of the crop.

Nodulation in soybean was highest with the lowest dose of inorganic fertilizer. Progressive increase in soybean nodulation was noticed with the application of farm compost in combination with poultry manure or vermicompost. *Rhizobium* inoculation was effective in enhancing the nodulation potential of soybean crop. Integrated use of organic manure, biofertilizers and lower fertilizer doses was found to be optimum in increasing the nodulation in soybean. Application of farm compost with poultry manure along with biofertilizers has enhanced the efficiency of inorganic fertilizer in increasing all yield attributes in soybean. Dual inoculation of soybean seeds with phosphate solubilizing bacteria and *Rhizobium* has improved the efficiency of combined use of farm compost and poultry manure as measured by increased test weight of soybean seeds.

Lower dose of fertilizer individually or in combination with biofertilizer enhanced the accumulation of carbohydrate and oil in seed. Manurial forms in combination with biofertilizers have beneficial effect on certain qualitative aspects, *viz.*, protein and oil content in seed.

Application of farm compost with poultry manure decreased the electrical conductivity of the soil. The organic carbon, available P and K status of the soil increased with the application of organic manures.

6.2 Cropping system 1: (Soybean – Mustard – Fodder cowpea)
Crop component: Mustard

The dry matter content of mustard crop increased with increased dose of inorganic fertilizer. The dry matter of mustard increased at early stages due to inorganic fertilizer application and at later stages due to organic sources. Integrated use of manure or biofertilizers with inorganic sources has enhanced biomass accumulation at higher dose of fertilizers. Fertilizer and biofertilizer use with or without application of cow's urine has increased all yield attributes in mustard. Lower doses of fertilizer alone and in combination with organic manure or biofertilizer showed positive response in [illegible], oil accumulation. The electrical conductivity of soil decreased with application of inorganic fertilizer. The organic carbon, available P and K have increased with application of inorganic fertilizers along with manure or biofertilizers.

6.3 Cropping system 1: (Soybean – Mustard – Fodder cowpea)
Crop component: Cowpea

Application of higher doses of fertilizers increased the biomass accumulation in cowpea. Lower doses showed good performance only if used in conjunction with manures or biofertilizers. Lower doses of fertilizers when supplemented with dual inoculation or organic manure application increased the nodulation and yield of cowpea. Carbohydrate content increased with lower fertilizer dose, while protein content decreased in forage of cowpea. Application of farm compost in combination with vermicompost or poultry manure increased the yield of cowpea. The carbohydrate and protein content increased with the application of poultry manure in combination with farm compost. The EC_{25} of soil decreased while enhancement of organic carbon, available P and K was observed in all combination containing organic sources of fertilizers.

6.4 Cropping system 2: (Blackgram – Wheat - Greengram)
Crop component: Blackgram

The dry matter accumulation pattern gradually increased with days of maturity. No difference in plant dry weight was observed with doses of fertilizers in combination with organic manure. Lower doses of fertilizers alone and in combination with organic

manures or biofertilizers enhanced nodulation in blackgram. Both dual inoculation and organic manure combinations increased yield of blackgram at lower doses of inorganic fertilizer application. Available P and K in soil increased when higher doses of fertilizer were augmented with organic manure and biofertilizer. The organic carbon status of soil increased in all combination containing organic source of nutrients.

6.5 Cropping system 2: (Blackgram – Wheat - Greengram)
Crop component: Wheat

Full dose of fertilizer caused highest dry matter accumulation in wheat but lower doses also showed comparable results due to residual fertility build up. Manurial forms and biofertilizers did not contribute individually to biomass accumulation. Effective tiller count, test weight and yield were highest when full dose of fertilizer was used in combination with vermicompost and poultry manure. The EC_{25} decreased when manurial forms were used in combination with inorganic fertilizers. The organic carbon and available P status in soil was moderate and available K was high when biofertilizer, organic spray and inorganic fertilizers were used in combination.

6.6 Cropping system 2: (Blackgram – Wheat - Greengram)
Crop component: Greengram

The fertilizer dose at lower level and farm compost in combination with vermicompost showed promising results with regard to dry matter accumulation in greengram. Nodulation increased with decrease in inorganic fertilizer application. It was found that organic sources of nutrients and biofertilizers enhanced nodulation in greengram when used with lower inorganic fertilizers. All agronomic parameters (pods/plant, seeds/pod, test weight, seed yield and biological yield) expressed complimentary effect of combination of inorganic fertilizers with manurial forms and biofertilizers. The EC_{25} was observed to be lower due to the integration of organic and inorganic sources of fertilizers. The organic carbon, available P and K were high in treatments containing vermicompost or poultry manure.

6.7 Soil properties as influenced by INM in legume based cropping system

The post harvest soil analysis indicated a decrease in EC_{25} when the crop component used was a legume. Higher EC_{25} was recorded with all INM packages in a non-legume (monocot or dicot) crop stand. Higher rates of inorganic fertilizers increased EC_{25} while all organic sources (manure, biofertilizer or organic spray) decreased the EC_{25}. Highest values of EC_{25} were observed in *rabi* season in both the cropping systems

Organic carbon decreased gradually in all INM packages in the 1[st] year but gradually increased to a maximum by the end of the 2[nd] year in both the cropping systems. At all levels of inorganic fertilizers different forms of organic manure or biofertilizers enhanced organic carbon content of soil. The organic carbon contribution of the non-legume component in experiment 1 (mustard) was higher than that of the 2[nd] (wheat) experiment.

All rates of fertilizer application in combination with organic manures increased the available P build up in soil after taking a legume in the cropping system. Non-legume component of cropping system decreased available P in soil. Vermicompost retained P in a more available form as was evident from the higher residual soil P content in plots treated with poultry manure. Blackgram-wheat-greengram cropping system generated higher residual P level in soil than soybean-mustard-fodder cowpea system in all INM packages.

Low available K in soil was found at the end of *zaid* season crop in both cropping systems in both the years. Uptake of K was highest by greengram followed by fodder cowpea as observed by least K values of soil. Biofertilizers in combination with inorganic fertilizers or organic manures retained more available K in soil.

The total biomass production per cropping system was higher in the 2[nd] year for both the experiments This is due to higher fertility build up promoted by organic matter incorporation.

BIBLIOGRAPHY

BIBLIOGRAPHY

Acharya, C.N.; Jain, S.P. and Jha, J. (1953) Studies on building up of soil fertility by the phosphatic fertilization of legumes: Influence of growing berseem on nitrogen content of the soil. *Journal of Ind. Soc. Of Soil Sc.* **1**: 55-64

Agboola, A.A.; Obigbesan, G.O. and Fayemi, A.A.A. (1975) Inter-relations between organic and mineral fertilizers in the tropical rainforest of West Nigeria. *FAO Soils Bulletin No.* **27**, p.337.

Ahlawat, I.P.S. and Ali, M. (1993) Fertilizer Management in Pulses. In *: Fertilizer Management in Food Crops* (Ed. Tandon, H.L.S.), FDCO, N.Delhi. pp. 114-138

Ahlawat, I.P.S.; Singh, A. and Saraf, C.S. (1981) Effect of winter legumes on the economy and productivity of suceeding cereals. *Experimental Agriculture* **17**: 57-62.

Ahlawat, I.P.S; Singh, A. and Singh, R.K. (1991) Effect of short-duration legumes on productivity of succeeding crop under rainfed conditions. *Ind. J. Agron.* **36** (4): 631-633

Ahmad, N and Jha, K.K. (1982) Effect of phosphate solubilizer on the dry matter yield of and phosphorus uptake by soybean. *Journ. Ind. Soc. Soil Sc.* **39**: 105-106

Alagawadi, A.R. (1998). Biological nitrogen fixation and its applicability. In *Organics in sustaining fertility and productivity*. pp.134–144 The University of Agricultural Sciences, Dharwad, India.

Anonymous (1980) A Report on Research Work in *Rabi* 1979. Agronomy and Soil Sci. Committee, MPAU, Rahuri, pp. FS 74-76

Ansari, N.N.; Ramesh, A. and Billore, S.D (1998) Effect of different organic manures oin the collar rot (*Sclerotium rolfsii*) incidence and yield of soybean. *J. Oilseeds Res.* **15** (2): 368-370

Antil, R.S.; Kumar, V. and Singh, M (1986) Effect of nitrogen on yield and its uptake of nitrogen at growth stages of raya (*B. juncea* Coss.). *Ind. J. Agron.* **31** (1): 37-44

Ardeshna, R.B.; Modhwadia, M.M.; Khanpara, V.D. and Patel. J.C. (1993) Response of greengram (*V. radiata*) to nitrogen, phosphorus and *Rhizobium* inoculation. Ind. *J. Agron.* **38** (3): 490-492

Arthamwar, D.N.; Shelke, V.B.; and Ekshing, B.S. (1996) Effect of N and P on yield attributes, seed and oil yield of Indian mustard (*B. juncea* Coss.). *Ind.J. Agron.* **41** (2): 282-285

Babu, S.C. and Subramanian, S.R. (1990) Substitution between organic manures and chemical fertilzers, under yield uncertainity – policy comparisons for irrigated and dryland farming systems. Sustainable Agric. – Issues, Perspectives and Prospects in Semi-Arid Tropics. Vol. 1 Proc. Ist Int. Symp. on Nat. Resources Management, pp 1-16

Bachav, P.R and Sabale, R.N. (1996) Effects of different sources of nitrogen o n growth parameters, yield and quality of soybean. *J. of Maharashtra Agric. Univ.* **21** (2): 244-247

Badiyala, D. and Verma, S.P. (1991) Integrated nitrogen management in maize (*Z. mays*) + soybean (*G. max*) – wheat (*T. aestivum*) cropping sequence under mid hills of H.P. *Ind. J. Agron.* **36** (4): 496-501

Balyan, J.S. and Seth, J. (1985) Effect of pure and intercropped stand of maize and cowpea on succeding wheat. *Ind. J. Agron.* **30**: 180-185

Bano, K; Kale, R.D. and Gajanan, G.N. (1987). Culturing of earthworm *E.eugeniae* for cast production and assessment of 'wormcast' as fertilizer. *J. Soil. Biol. Ecol.* **2**, Sept. 1987

Baruah, R.; Barthakur, H.P. and Thakur, A.C. (1995) Effect of indigenous VAM and *Rhizobial* inoculation on growth and nodualtion of greengram (*V. radiata*) as affected by sources of phosphorus. Proc. Of Seminar on Problems and Prospects of Agricultural Research and Development in North-East India, AAU, Assam. Nov. 27-28, 1995. pp.213-219

Bhatia, K.S and Shukla, K.K (1982) Effect of continuous application of fertilizers and manure on some physical properties of eroded alluvial *soils Journal of Ind. Soc. of Soil Sc.* **30** (1): 33-36.

Bhogal, N.S.; Sakal, R. Singh, A.P. and Sinha, R.B. (1993) *J. Ind. Soc. Soil Sci.* **41**: 75-78

Bisht, J.K. and Chandel, A.S. (1991) Effect of INM on leaf-area index, photosynthetic rate and agronomic and physiological efficiencies of soybean (*G. max). Ind. J. Agron.* **36** (Supplement): 129-132

Bisht, J.K. and Chandel, A.S. (1996) Effect of INM on yield attributes, yield and quality of soybean (*G.max* L. Merrill) *Annals of Agric. Res.* **17** (4): 360-365

Biswas, B.C.; Yadav, D.S. and Maheswari, S. (1985). Biofertilizers in Indian Agriculture. *Fertilizer News* **30** (10): 20-28.

Biswas, T.D.; Sain, B.L. and Naskar, G.C. (1975) Effect of crops and crop rotation on soil structure and soil water retention characteristics. *Ind. Agric.* **19** (1): 97-105

Blondel, D. (1971) Organic recycling in Asia. *FAO Soils Bulletin.* p.17.

Bobde, G.N.; Deshpande, R.M.; Khandalkar, D.M. and Turankar, V.L. (1998) Nutrient management of soybean (*G. max*) – based cropping system. *Ind. J. Agron.* **43** (3): 390-392

Chen, T.W. (1993) Nitrogen fixation of *Azorhizobium* in artificially induced root para-nodules in wheat. *Sci. China*, **35**: 1463-1469

Chinnusamy, J. and Rangasamy, A (1997) INM in rice based cropping system linked with lowland integrated farming system. *Fert. News* 42 (3): 25-30

Chittapur, B.M. (1998) Composting of Organic Wastes In: *Organics in sustaining fertility and productivity.* pp. 164–172 The University of Agricultural Sciences, Dharwad , India.

Chovatia, P.K.; Ahlawat, R.P.S. and Trivedi, S.J. (1993) Growth and yield of summer greengram (*V. radiata*) as affected by different dates of sowing, *Rhizobium* inoculation and levels of phosphorus. *Ind. J. Agron.* 38 (3): 492-494

Dahatonde, B.B. and Shava, S.V. (1992) Response of Soybean (G. max) to nitrogen and Rhizobium inoculation. *Ind. J. Agron.* 37 (2): 370-71,

Daterao, S.H. and Lakhdive, B.A (1992) Optimization of fertilizer nitrogen for wheat (*T. aestivum* L.) under the influence of preceding crop and seed inoculation with bacterial culture. *Ind. J. Agron.* 37 (1):60-64

Dayal, D. and Agarwal, S.K. (1998) Response of sunflower (*H. annuus*) to organic manures and fertilizers. *Ind. J. Agron.* 43 (3): 469-473

Dhillon, N.S.; Brar, B.S.; Dhaliwal, C.S. (Ed.) Arora, R. (Ed.): Randhawa, N.S (Ed.) and Dhawan, A.K.Integrated management of FYM and inorganic fertilizers in rice – wheat cropping system in north western India. Ecological Agriculture and Sustainable development: Vol. 1 Proc. Int. Conf. Eco. Agric. towards sustainable dev. Nov. 15-17, 1997 pp. 604-612

Dobereiner, J.; Reis, V.M; Paula, M.A.and Olivares, F. (1993) Endophytic diazotrophs in sugarcane, cereals and tuber plants. In: *New horizons in nitrogen fixation.* Eds: R. Palacios, J. Mora, W.E. Newton, Dordrecht: Kluwer Academic publisher, pp. 671-676.

Dravid, M.S. and Goswami, N.N. (1988) Relative efficiency of mustard and sunflower in utilizing soil phosphorus in presence of P, Zn and FYM under normal and saline soil conditions. *Journal of Nuclear Agric. Biol.* 17: 18-22

Dubey, O.P. and Khan, R.A. (1993) Effect of nitrogen and sulphur on sulphur content in Indian mustard (*B. juncea*) and their residual balance in soil. *Ind. J. Agron.* **38** (4):582-587

Dubey, R.P. and Verma, B.S. (1999) Integrated nutrient management in rice (*O. sativa*) – rice – cowpea (*V. unguiculata*) sequence under humid tropical Andaman Islands. *Ind. J. Agron* **44** (1): 73-76

Dubey, S.K. (1992) Effect of mycorrhizae, *Bradyrhizobium* inoculation and phosphorus level on nodulation, yield and yield attributes in soybean (*G. max*). *Ind. J. Agric. Sc.* **63** (11): 737-739

Dubey, S.K. (1998) Response of soybean (*G. max*) to biofertilizers with and without nitrogen, phosphorus and potassium on swell-shrink soil. *Ind J. Agron* **43** (3): 546-549

Dubey, S.K.; Sharma, R.S. and Vishwakarma, S.K. (1997) INM for sustainable productivity of important cropping systems in M.P. *Ind. J. Agron* **42** (1): 13-17.

Dudhat, M.S.; Malavia, D.D.; Mathukia, R.K. and Khanpara, V.D. (1996) Effect of organic manures and chemical fertilizers on wheat (*T. aestivum* L.) and their residual effect on greengram (*V. radiata*) *Guj. Agric. Univ. Res.* J. **22** (1): 4-8

Dwivedi, M.; Upadhayay, R.M. and Dwivedi, G.K. (1993) Effect of inorganic, organic and biofertlizers on yield and nutritional quality of blackgram and wheat grown in sequence. *Ind. J. Agric. Chem.* **26** (2-3): 111-122

Dwivedi, V.D.; Namdeo, K.N. and Chaurasia, S.C (1998) Economic feasibility of legume and non-legume-based double cropping systems under rainfed conditions. *Ind. J. Agron.* **43** (3): 404-406

FAO, (1995) Production Year Book **49**, Food and Agriculture Organization of United Nations, Rome, pp. 106

Gangwar, K.S. and Singh, Y. (1992) Integrated nutrient management in fodder sorghum (*S. bicolor*) – Gram (*C. arietinum*) cropping sequence under dryland conditions. *Ind. J. Agron.* **37** (1):107-109

Gaur, A. C. and Sadasivan, K.V. (1991) Organic manures in aid of fertilizers. Ind. Farming **31** (7): 31-32

Gaur, A.C. (1982) Review of Soil Research in India, Part-I, In: Proceedings of 12th International Soil Science Congress, N.Delhi pp.278-305

Geethakumari, V.L. and Shivashankar, K (1991). Studies on organic amendment and CO_2 enrichment in ragi/ soybean intercropping systems. *Ind. J. Agron.* **36** (2):202-206

George, S.; Pillai, G.R. and Pushpakumari, R. (1998) Influence of biofertilizers on productivity of guinea grass intercropped in coconut gardens. *Ind. J. Agron.* **43** (4): 622-627

Gill, M.S.; Singh, T. and Rana, D.S. (1994) Integrated nutrient management in rice (*O. sativa*)- wheat (*T. aestivum*) cropping sequence in semi-arid tropic. *Ind. J. Agron.* **39** (4): 606-608

Gomez, K.A. and Gomez, A.A. (1984). Statistical procedures for agricultural research. *Int. Rice Res.* Inst., Philipines, Wiley-Interscience (Publn).

Gopalkrishnan, B. and Palaniappan, S.P. (1992) Influence of Mussorie rock phosphate on available nutrients in soybean – sunflower cropping system. *J. Ind. Soc. Soil Sci.* **40**: 474-477

Goswami, S.; Khan, R.A.; Vyas, K.M.; Dixit, J.P. and Namdeo, K.N. (1999) Response of soybean (*G. max*) to levels, sources and methods of phosphorus application. *Ind J. Agron.* **44** (1): 126-129

Halvankar, G.B.; Taware, S.P/ and Raut, V.M. (1999) Response of some soybean (*G. max*) varieties to different fertility levels. *Ind. J. Agron.* **44** (3): 605-608

Hamid, A. (1988) Nitrogen and carbofuran effect on the growth and yield performance of mungbean. *Journal of Agron. and Crop Sci.* **161** (1): 11-16

Hegde, D.M. (1992) Cropping System Research Highlights, pp. 39. Co-ordinators' report, Project Directorate for Cropping Systems Research, Modipuram, Meerut. Presented in 20th Workshop at TNAU, Coimbatore.

Hegde, D.M. (1998) Effect of integrated nutrient management on productivity and soil fertility in pearl millet (*P. glaucum*) – wheat (*T. aestivum*) cropping system. *Ind. J. Agron.* **43** (4): 580-587

Hedge, J.E. and Hofreiter, B.T. (1962) In: *Carbohydrate Chemistry* **17** (Eds. Whistler, R.L. and Be Miller, J.N.) Academic Press, New York.

Hiremath, R.V. and Kalappanavar, I.K. (1998). Organic amendments for control of soil borne pathogens. In *Organics in sustaining fertility and productivity*. pp. 263–274 The University of Agricultural Sciences, Dharwad, India.

Hsieh, C.F.; Hsu, K.N. (1995) Effect of continuous use of organic manures on the growth and yield of vegetable soybean and cabbage. Bulletin of Taichung Dist. *Agric. Improvement Stn*. 46 (1-10)

Itnal, C.J. (1998) Fertility Management in Dryland Agriculture – Principles and Practices. In: *Organics in sustaining fertility and productivity*. pp. 78–90 The University of Agricultural Sciences, Dharwad , India.

Itnal, C.J., (1998). Organic farming for sustainable agricultural production. In *Organics in sustaining fertility and productivity*. pp. 5–12 The University of Agricultural Sciences, Dharwad, India.

Jain, R.C. and Jain, P.M. (1993). Effect of preceding rainy-season crops on yield and nutrient uptake by wheat (*T. aestivum*) under different levels of nitrogen. *Ind. J. Agron.* **38** (4): 643-644

Jain, R.C. and Tiwari, R.J. (1995) Influence of FYM and sugar pressmud and yield and nutrient content of soybean (*G.max* L. Merrill) in medium black soil of M.P. *Crop Res*., Hissar. **9** (2): 215-217

Jain, R.C.; Tiwari, R.J. and Singh, K. (1995) Effect of FYM and sugar pressmud on productivity and quality of soybean (*G.max* L. Merril) *Crop Res*. Hissar. **9** (2): 229-232

Jawale, S.M.; Jadhav, A.S. and Patil, V.G. (1998) Productivity and economics of legumes – winter sorghum (*S. bicolor*) double cropping systems under tillage practices in western Maharashtra. *Ind. J. Agron*. **43** (3): 396-403

Jayapaul, P and Ganesaraja, V (1990) Studies on response of soybean varieties to nitrogen and phosphorus. *Ind. J. Agron*. **35** (3): 329-330

Jena, U.C.; Pradhan, L. and Mohapatra, B.K. (1995) Effect of N, P and cutting management on fodder yield of cowpea (*V. unguiculata* (L.) Walp.) *Ind. J. Agron*. **40** (2): 321-322

Kale, R.D. (1993). Development of vermicompost technology in Karnataka state

Kale, R.D; Mallesh C.B; Bano, K and Bagyaraj.D.J. (1990). Influence of vermicompost application on the available micronutrients and selected microbial population in a paddy field. Paper presented at IV Int. Symp. On Earthworms, Avignon, France, June 1990

Khan, G.M. and Agarwal, S.K. (1985) Influence of sowing methods, moisture stress and nitrogen levels on growth, yield components and seed yield of mustard. *Ind. J. Agrl. Sciences* **55**: 324-332

Khandkar, U.R. and Shinde, D.A. (1991) Phosphorus nutrition of blackgram as influenced by P and S application. *Journ. Ind. Soc. Soil Sc*.**39**: 583-585

Kulkarni, J.H. (1998) Role of Microorganisms in Soil Fertility. In: *Organics in sustaining fertility and productivity*. pp. 129–133 The University of Agricultural Sciences, Dharwad , India.

Kumar, R. and Kumar, S. (1997) INM for sustained wheat (*T. aestivum*) production in sandy loam soils of Haryana. *Annals of Biol.* **13** (1):27-29

Kumar, S. and Prasad, N.K. (1999) Soil fertility and yield as influenced by different legume-wheat (*T. aestivum*) sequences. *Ind. J. Agron.* **44** (3): 488-492

Kunnal, L.B. (1998) Economic evaluation of organic farming. In *Organics in sustaining fertility and productivity.* pp.294–299 The University of Agricultural Sciences, Dharwad, India.

Laddha, K.C. and Totawat, K.L. (1998) Interactive effect of tillage and phosphate fertilization in conjuction with FYM to sorghum + greengram intercropping system on physico-chemical properties of the soil. *Annals of arid zone* **37** (1): 75-81

Latha, K.R. and Subramanian, S. (1991) INM in sorghum (*S. bicolor*) intercropping system under dryland vertisols. *Ind. J. Agron.* **36** (Supplement): 268-270.

Lopes, A.J. de R.; Stamford, N.P.; Figueiredo, M.V.B.; Burity, H.A. and Forraz, E.B. (1996) Effects of application of urban compost, mineral nitrogen and mineralizing agents on N_2 fixation and yield in cowpea. Revista Brasileira de Cieneia de Solo **20** (1): 55-62.

Madhavi, B.L.; Reddy, M.S. and Rao, P.C. (1995) INM using poultry manure and fertilizers for maize. *J. Res.* APAU **23** (3-4): 1-4

Mahakulkar, B.V.; Wanjari, S.S.; Atale, S.B.; Potdukhe, N.R. and Deshmukh, J.P. (1998) Integrated nutrient management in sorghum (*S. bicolor*) – based cropping system. *Ind. J. Agron.* **43** (3): 376-381

Mahanta, B. and Borah, A. (1998) Effect of organic amendments for the management of *Meloidogyne incognita* on greengram and blackgram. *J. Agric. Sci. Soc. N.E. India.* **11** (1): 73-76

Maheshwari, S.K.(1974). Response of greengram to inoculation and levels of N and P and their economics. *JNKVV Res. J.* **8** (2): 157-8

Maheswarappa, H.P.; Nanjappa, H.P.; Hegde, M.R. and Prabhu, S.R. (1999) Influence of planting material, plant population and organic manures on yield of East Indian galanga (*Kampferia galanga*), soil physico-chemical and biological properties. *Ind. J. Agron.* **44** (3): 651-657

Malik, N. and Jaiswal, L.M. (1993) Integrated use of organic and inorganic nitrogen sources and levels of N in wetland rice (*O. sativa*) in eastern Uttar Pradesh. *Ind. J. Agron.* **38** (4): 641-643

Mandal, S; Chakraborthy, T and Datta, J.K. (1997) Influence of growth retardant and rock phosphate on growth and development of greengram (*V. radiata* (L.) Wilezeck) *Ind. J. Plant Physio.* **2** (1): 32-35

Mascarenhas, H.A.A.; Braga, N.R.; Miranda, M.A.C; Feitosa, C.T. and Bataglia, O.C. (1980) *Boletim Tecnico de Institute Agronomico* Brazil **63**: 12

Mathan, K.K.; Francis, H.J. and Arunachalam, L. (1994) Influence of INM on the yield, protein content and uptake of nutrients by pigeonpea (*Cajanus cajan*). *J. Ind. Soc. Soil Sci.* **42** (4): 558-561

Meena, J.N.; Sharma, S.N. and Singh, S. (1993) Effect of cropping system, residual nitrogen and phosphorus on yield and nutrient uptake by summer greengram (*V. radiata*). *Ind. J. Agron.* **38** (10): 124-126

Meenakumari, K.S. and Nair, S.K (1992) Effect of phosphatic fertilizer application on VAM infection in cowpea. *Agric. Res. J. of Kerala.* **30** (2): 129-131.

Miller, C.E. (1938) Plant physiology. Edn. 2 pp. 1165 McGraw-Hill Book Co. Inc. N.York and London.

Mishra, C.M. (1993) Response of blackgram (*V. mungo*) varieties to levels of phosphorus under rainfed conditions. *Ind. J. Agron.* **38** (3): 489-490

Mishra, S.N.; Paikaraya, R.K. and Mishra, K.N. (1999) Effect of lime, organic and inorganic nutrients on wheat (*T. aestivum*) – soybean (*G. max*) cropping systm in acidic red soils. *Ind. J. Agron.* **44** (1): 26-29

Moharram, T.M; Mohandas, E.L. and Badawi, M.A (1999) Effect of inoculation and organic manure application on symbiotic N_2 fixation, microbial biomass and nutrients availability in sandy soils cultivated with soybean and peanut. *Annals of Agric. Microbiol. Sci.* Cairo.

Morant, M.A.; Casasola, J.L.; Brooks, C.B.; Philip, E.T; Mitchell, V.G; Orr, C.R. (1997) Poultry litter enhances soybean productivity in field infested with soybean syst nematode. *J. Sustainable Agric.*, Univ. Maryland Eastern Shore, U.S.A

More, S.D. and Ghogale, D.P. (1992) Soil N balance as influenced by preceeding *kharif* pulse crops. *J. Maharashtra Agric. Univ.* **17** (13): 473-474

Morey, D.K and Bagde, M.G. (1992) Effect of *kharif* legumes on yield, nitrogen economy of suceeding wheat and economics of cropping system. *J. Maharashtra Agric. Univ.* 7 (1): 26-29

Muir, J.H and Hedge, J.A (1999) Influence of poultry litter and phosphorus on soybean on saline soils. *Res. Series Arkansas Agric. Expt. Stn.* **463**: 81-83.

Mukherjee, S.K. and Singh, K. (1984) Chemistry of soil organic matter in relation to nitrogen availability. Bulletin, *Ind. Soc. Soil Sc.* **13**: 20-29 (fide Mann et al., 1973).

Murthy, V.R; Havanagi, G.V and. Nanjappa H.V (1990). Response of cowpea to fertilizer and protective irrigation. *Ind. J. Agron.* **35** (3): 330-331

Nagaraju, A.P.; Shambulingappa, K.G. and Sridhara, S. (1995) Efficiency and sources of fertizer phosphorus and organic manure on growth and yield of cowpea (*V. unguiculata* (L.) Walp.) *Crop Res.* Hissar. 9 (2): 241-245

Nambiar, K.K.M. and Abrol, I.P. (1992) Long-term fertilizer experiments in India-An overview, *Fertilizer News*. **34** (4): 11-20, 26

Nambiar, K.K.M.; Soni, P.N.; Vats, M.R; Sehgal, D.K. and Mehta, D.K (1992) Annual report 1987-88 / 1988-89. All India Co-ordinated Research Project on Long-term Fertilizer Experiment, ICAR, and N.Delhi.

Navale, K.B. and Gaikwad, C.B. Growth behaviour of soybean as influenced by INM under irrigated condition. *J. of Maharashtra Agric. Univ.* **23** (1): 94-95

Nayak, K.R.; Gowda, B.K.L.; Bhat, S.S. and Krishnamurthy, N. (1995) The effect of organic manures and inorganic fertilizers on the growth and yield of fingermillet (*E. coracana* Gaertn.) under rainfed conditions. *Ind. Agriculturist* **39** (1): 21-26

Negi, S.C.; Singh, K.K. and Thakur, R.C. (1992) Economics of phosphorus and farmyard manure application in wheat (*T. aestivum*) – maize (*Z. mays*) sequence. *Ind. J. Agron.* **37** (1): 30-33

Nema, M.L; Pathak, S.S, Pahalwan, D.K. and Rao, S.S (1985) Agronomic evaluation of different varieties of soybean. *Seeds and Farms* **XI**. (8): 29-31.

Newaj, R. and Yadav, D.S. (1994) Changes in physico-chemical properties of soil under intensive cropping systems. *Ind. J. Agron.* **39** (3): 373-378

Nimje, P.M. and Seth, J. (1988) Effect of phosphorus and FYM on nutrient uptake by soybean. *Ind. J. Agron.* **33** (2): 139-142

Okon, Y. and Kapulinth, Y. (1986) Development and function of *Azospirillum* inoculated roots. *Plant and Soil* 90: 3-16

Palled, Y.B. (1998) Integrated nutrient management in pulses and oilseeds. In *Organics in sustaining fertility and productivity*. pp. 200–211 The University of Agricultural Sciences, Dharwad, India.

Panse, V.G. and Sukhatme, P.V. (1995). Statistical methods for agricultural workers (IV Edn.). ICAR, N.Delhi

Parasuraman, P.; Budher, M.N.; Manickasundaram, P. and Nadanam, M. (1998) Response of sorghum (*S. bicolor*), finger millet (*E. coracana*) and groundnut (*A. hypogea*) to tank silt application and combined use of organic matter and inorganic fertilizer under rainfed condition. *Ind. J. Agron.* **43** (3): 528-532

Patel, B.A.; Patel, R.H.; Patel, M.V. and Amin, A.U (1992) Effect of combined application of organic sources and inorganic fertilizer on wheat (*T. aestivum*). *Ind.J. Agron.* **37** (1): 52-54

Patel, F.M. and Patel, L.R. (1991) Response of greengram varieties to phosphorus and *Rhizobium* inoculation. *Ind. J. Agron.* **36** (2):295-297

Patel, J.R. and Patel, Z.G. (1994) Effect of foliar fertilization of nitrogen and phosphorus on growth and yield of summer greengram (*V. radiata*). *Ind. J. Agron.* **39** (4): 578-580

Patel, J.R. and Shelke, V.B. (1998) Effect of farmyard manure, phosphorus and sulphur on growth, yield and quality of Indian mustard (*B. juncea*) *Ind. J. Agron.* **43** (4): 713-717

Patel, R.G.; Patel, M.P.; Patel, H.C. and Patel R.B. (1984) Effect of graded levels of nitrogen and phosphorus on growth, yield and economics of summer mungbean. *Ind. J Agron.* **29** (3): 291-294

Patel, R.H.; Meisheri, T. G. and Patel, J.R. (1996) Analysis of growth and productivity of Indian mustard (*B. juncea*) in relation to FYM, N and source of fertilizer. *J.Agron. Crop Sci.* 177 (1): 1-8

Patel, R.H.; Meisheri, T.G.; Patel, B.K. and Patel, J.R. (1998) Yield, nutrient content and uptake by Indian mustard (*B. juncea* (L.) Czernj. and Cossonj.) as influenced by FYM, N, and source of fertilizer. *Guj. Agric. Univ. Res. J.* **23** (2): 1-8

Patel, R.H.; Patel, N.M.; Patel, Z.G. and Patel L.K. (1992) Role of bio-fertilizer in productivity of finger millet (*E. coracana*). *Ind. J. Agron.* 38 (1): 119-120

Patil, C.V. (1998). Use of natural sources of nutrients in maintaining soil fertility. In *Organics in sustaining fertility and productivity.* pp. 39–45. The University of Agricultural Sciences, Dhàrwad, India.

Patil, M.P.; Hulamani, N.C.; Athani, S.I. and Patil, M.G. (1997) Response of potato (*S. tuberosum* L.), cv. Kufri chandramukhi to INM. *Advances in Agric. Res. Ind.* 8: 135-139

Patil, M.P.; Hulamani, N.C.; Athani, S.I. and Patil, M.G. (1998) Response of new tomato genotype Megha to INM. *Adv. Agric. Res. In India* 9: 39-42

Patil, S.K.; Pisal, A.A. and Desale J.S. (1992) Response of fodder maize (*Z. mays*) to biofertilizers. *Ind. J. Agron.* 37 (2): 357-358

Patnaik, S; Panda, D. and Dash, R.N. (1989) Long-term fertilizer experiments with wetland rice. *Fertilizer News* 34 (4): 47-52

Pawar, R. B. (1997). Dynamics of earthworm soil – plant relationship in semi-arid tropics. (Ph.D. Thesis). UAS., Dharwad

Pellett, L.P. and Young, V.R. (1980) *Nutritional Evaluation of Protein Foods* U.N Univ. Publ.

Poleshi, C.M. (1998) Nutrient availability in relation to soil properties. In *Organics in sustaining fertility and productivity.* pp. 17–25 The University of Agricultural Sciences, Dharwad , India.

Prabhakar, A.S. and Patil, B.N. (1998) Assessment of Long Term Manurial Studies in Relation to Soil Fertility and Crop Productivity. In: *Organics in sustaining fertility and productivity.* pp. 91–94 The University of Agricultural Sciences, Dharwad , India.

Pradhan, L.; Rout, D. and Mohapatra, B.K. (1995) Response of soybean to nitrogen and phosphorus. *Ind. J. Agron.* 40 (2): 305-306

Prasad, C.R; Shamimuddin; Singh, B.N.; Jha, K.K. and Mandal, S.C. (1971). Effect of continuous application of manures, fertilizers and lime on some chemical properties of acid red loam soil of Bihar. *Proc. Int. Symp. Soil Fert. Evaln.* (Vol. 1), N.Delhi, pp. 865-872

Prasad, F.M.; Chandra, A.; Varshney, M.L and Verma, M.M (1991) Growth, yield, dry matter, nutrients uptake by mustard (*B. juncea*) in alluvial soil as influenced by phosphorus and organic matter. *New Agric.* 2 (1): 31-34

Prasad, J. (1977) Effect of different levels of phosphorus on growth and yield of different *kharif* legumes. M.Sc. (Agron.), Thesis, JNKVV, M.P.

Prasad, J. and Hajare, T.N. (1992) Performance of two soybean (*G. max*) varieties under different agronomic practices in Vertic Usttochrepts soil of Vidarbha. *Ind. J. Agron.* 37 (2): 366-368

Prasad, J. and Sanoria, C.L. (1981) Response of bengalgram seed bacterization and phosphorus. *Seed and Farms.*7 (4): 31-32

Prasad, J.V.N.S.; Ramiah, N.V. and Satyanarayana, V. (1993) Response of soybean (*G. max*) to varying levels of plant density and phosphorus. *Ind. J. Agron.* 38 (3): 494-495

Prasad, R. (1990) Fertilizer Use Efficiency. In: Agronomic Res. Towards Sustainable Agric. Eds. Singh, K.N. and Singh, R.P. *Ind. Soc. Agron.*, N. Delhi pp-57-68.

Punia, B.S.; Porwal, B.L. and Gaur, B.L. (1993) Response of mustard (*B. juncea*) to phosphorus on vertisols of Rajasthan. *Ind. J. Agron.* 38 (1): 142-143

Radder, G.D. (1998) Integrated Farming Systems for Sustainability in Agriculture. In *Organics in sustaining fertility and productivity.* pp.321-330 The University of Agricultural Sciences, Dharwad, India.

Raghuwanshi, R.K.S. and Umat, R. (1994) INM in sorghum (*S. bicolor*) – wheat (*T. aestivum*) cropping system. *Ind. J. Agron.* 39 (2): 193-197

Raju, R.A.; Reddy, K.A. and Reddy, M.N. (1993) Integration of nutrient management in wetland rice (*O. sativa*). *Ind. J. Agric. Sc.* 63(12): 786-789

Ram,G.; Patel, J.K.; Chame, N.N. and Choudhary, K.K. (1992) Single and combined effect of biological, organic and inorganic fertilzers on yield of sunflower and soil properties under rainfed conditions., *Advances in Plant Sci.* 5 (1): 161-167

Ramamoorthy, K. and Arokiaraj, A. (1997) Agronomic effectivenes of organic sources and mussorie rock phosphate to phosphorus economy in rainfed greengram. *Madras Agric. J.* 85 (10): 593-595

Ramamurthy, V. and Shivashankar. K. (1996). Effect of organic matter and Phosphorus on growth and yield of Soybean (*G. max*) *Ind. J. Agron* 41 (1): 65-68.

Ramamurthy, V.and Shivashankar, K. (1996) Residual effect of organic matter and phosphorus on growth, yield and quality of maize (*Z. mays*). *Ind. J. Agron.* 41 (2): 247-251

Ranwa, R.S.and Singh, K.P. (1999) Effect of integrated nutrient management with vermicompost on productivity of wheat (*T. aestivum*). *Ind. J. Agron.* 44 (3): 554-559.

Rao, M.M. and Sharma, K.C. (1976) Effect of upand multiple cropping systems and fertilizer constraints on some chemical properties of soil. *Ind. J. Agrl. Sc.* 46 (6):285-291

Rao, N.S.S (1982) Biofertilizer in agriculture; pp. 186, Oxford and IBH Publishing Co., N.Delhi.

Rao, N.S.S. (1980) Role of bacteria in crop production. *Ind. Farming* 30(7): 71-76.

Rao, S.S. and Sitaramayya, M (1997) Changes in total and available soil N status under INM of rice. *J. Ind. Soc. Soil Sci.* 45 (3): 445-449

Reddy, K.M.; Reddy, S.C. and Reddy, T.Y. (1992) Dry-matter production, distribution and nutrient content of greengram (*Phaseolus radiatus*) varieties as influenced by fertility treatment. *Ind. J. Agron.* 37 (2): 268-272

Reddy, T.R; Rao, M and Rao, K.R. (1990) Response of soybean (*G.max* (L.) Merril) to nitrogen and phosphorus. *Ind. J. Agron.* 35 (3) : 308-310

Richardson, D.A.; Jordon, D.C. and Garaed, E.H. (1957) The influence of combined nitrogen on nodulation and nitrogen fixation by *Rhizobium melilotii. Canadian Journal of Plant Science* **36**: 91-94

Roy, R.N. (1992). Integrated plant nutrition systems-An overview. In: Fertilizers, Organic manures, Recyclable wastes and Biofertilizers – components of integrated plant nutrition. Ed. H.L.S. Tandon. FDCO. N. Delhi pp. 1-11.

Roy, R.N. and Braun, H. (1984). *Proceedings of Seminar, Systems Approach to Fertilizer Industry*, 1983 N.Delhi, Fertiliser Association of India, Part II, ABS 1-1/1-23

Sadanandan, N. and Mahapatra, I.C. (1972) Effect of various cropping patterns on pH of upland alluvialrice soils. *Ind. J. Agron.* **18**: 41-44

Sadasivam, S. and Manickam, A. (1992) *Biochemical Methods 2nd Edn.* N.A.I. (P) Ltd. and TNAU pp 22-23.

Sahoo, S.C and Panda, M.M (1999) Direct and residual effect of fertilizer and manure on a maize (*Zea mays*). – mustard (*B. campestris*) cropping sequence. *Crop Res.* Hissar. **17** (1): 118-120

Sankaran, A. (1996) Eco-farming – Relevance and rewards. In: *Survey of Ind. Agric.*, The Hindu. pp. 35-37

Santhi, R. and Kothandaraman, G.V (1995) Effect of endomycorhyzza colonisation and phosphorus sources on the phosphorus recovery, nutrient uptake and growth of greengram. *Ind. J. Agric. Res.* **29** (4): 209-214

Saran, G. and Giri, G. (1990) Influence of nitrogen, phosphorus and sulphur on mustard under semi-arid rainfed conditions of north-west India. *Ind. J. Agron.* **35** (2); 131-136

Sardana, V. and Sidhu, M.S (1994) Effect of INM on the quality and yield of Indian rape (*B. campestris*, var. *toria*) + Swede rape (*B. napus*) intercropping system. *Crop Res.* Hissar **8** (3): 431-436

Sarkar, A.K.; Mathur, B.S.; Lal, S. and Singh, K.P. (1989) Long-term effect of manure and fertilizer on important cropping systems in sub-humid red and laterite soils. *Fertilizer News* **34** (4):71-80

Sarkar, R.K. and Banik, P. (1991) Response of greengram to nitrogen, phosphorus and molybdenum. *Ind. J. Agron.* **36** (1): 91-94

Sarkar, R.K.; Karmakar, S. and Chakraborty, A. (1993) Response of summer greengran (*Vigna radiata*) to nitrogen, phosphorus application and bacterial inoculation. *Ind. J. Agron.* **38** (4): 578-581

Sarkar, S. and Singh, S.R. (1997) INM in relation to soil fertility and yield sustainability under dryland farming. *Ind. J. Agric. Sci.* **67** (9): 431-433

Sarmah, P.C.; Katyal, S.K. and Verma, O.P.S. (1992) Growth and yield of sunflower (*H. annuus*) varieties in relation to fertility level and plant population. *Ind. J. Agron.* **37** (2): 285-289

Sawarkar, S.D. and Goydani B.M. (1996). Effect of Fertilizer and Azospirillum on grain yield of rainfed wheat (*T. aestivum*). *Ind. J. Agron.* **41** (3): 409-11

Selvi, S. and Ramaswami, P.P. (1995) Residual effects of INM in rice – rice – pulse cropping sequence.

Shah, J.P. and Joshi H.U. (1986) Biofertlizer for improving production of cereal crops. *Fertiliser News* **31** (12): 75-77.

Shah, S.K.; Sharma, G.L. and Vyas, A.K. (1994) Growth parameters, biomass production and nutrient uptake by blackgram (*V. mungo*) as influenced by phosphorus, potassium and plant-growth regulators. *Ind. J. Agron.* **39** (3): 481-483

Sharma, C.M. and Bhardwaj, S.K. (1993) Agronomic effectiveness of indegenous rock phosphate with and without organics on soybean. *Himachal J. Agric. Res.* **19** (1-2): 86-89

Sharma, P.K.; Diksit, P.R. and Tembhare, B.R. (1985) Yield and nutrient uptake by wheat as influenced by nitrogen application and *Kharif* legumes grown with varying starter doses of nitrogen and inoculation. *Legumes Research* **2**: 77-80

Sharma, R.A. (1992) Efficient water use and sustainable production of rainfed soybean and safflower through conjunctive use of organics and fertilizer. *Crop Res.* Hissar **5** (2): 181-194

Sharma, R.K.; Kolhe, S.S. and Tripathi, R.S. (1994) Influence of level of phosphorus, interculture and IAA on growth and nodulation in greengram (*V. radiata) Ind. J. Agron.* **39** (3): 479-481

Sharma, R.K.; Shrivastava, U.K.; Tomar, S.S.; Tiwari, P.N. and Yadav, R.P. (1999) Nutrient management in soybean (*G. max*) – mustard (*B. juncea*) crops sequence. *Ind. J. Agron.* **44** (3): 493-498

Sharma, S.K. and Puri, U.K (1987) Nutro management studies in rainfed crops and oil seed crops. *J. Plant Nutrn.* **10**: 9-16

Shinde, D.A. and Ghosh, A.B. (1971). Effect of continuous cropping and manuring on crop yield and characteristics of medium black soil. Proc. Int. Symp. Soil Fert. Evaln. (Vol. 1), N.Delhi, pp. 905-916

Shivashankar, K. (1998) Impact of agricultural practices on ecology and environment. In: *Organics in sustaining fertility*. pp.13-16 . The University of Agricultural Sciences, Dharwad, India

Shivshankar, K.; Vlassak, K. and Livens, J. (1986) A comparison of the effect of straw incorporation on yield of soybeans. *J. Agric. Sci. Comb.* **87**: 181-185

Shrivastava, S.N.; Namdeo, K.N.; Tripathi, A.R. and Pandey, R.P. (1980) Effect of row spacing and levels of phosphorus on blackgram (*V. mungo*) or (*V. radiata* Hepper). *Madras Agricultural Journal* **67**: 771-773

Shroff, V.N and Devasthali, S. (1992) Earthworm Farming- Scope and limitations. Proceedings of National Seminar on Natural Farming(L.L. Somani, Ed.)

Shroff, V.N. (1994) Integrated plant nutrient management. Paper presented at Annual Soybean workshop, UAS, Dharwad. April 25-27, 1994

Shukla, S.K and Dikshit, R.S (1996) Effect of *Rhizobium* inoculation, Plant population and phosphorus on growth and yield of summer greengram (*V. radiata* (L.) Wilezeck) *Ind. J. Agron* **41** (4): 611-615

Singh, A.K.; Choudhary, R.K. and Sharma, R.P.R. (1993) Effect of inoculation and fertilizer levels on yield, yield attributes and nutrient uptake of greengram (*V. radiata*) and blackgram (*V. mungo*). *Ind. J. Agron.* **38** (4): 663-665

Singh, A.K; Choudhury, R.K and Sharma, R.P.R (1993) Effect of inoculation and fertilizer levels on yield, nutrient uptake and economics of summer pulses. *J. of Potassium Res.* **9** (2): 176-178

Singh, C.R.; Prasad, J. and Parihar, S.S. (1998) Integrated nutrient management in rice – wheat crop rotation. *Advances in Plant Sciences* **11** (1): 175-178

Singh, G.B. (1996) Integrated Nutrient Management- Strategy for balanced usage. *Survey of Ind. Agric.*, The Hindu. pp. 151-153

Singh, G.B. and Yadav, D.V. (1992) INSS in sugarcane and sugarcane-based cropping system. *Fertlizer News* **37** (4): 15-22

Singh, K and Srivastava, O.P. (1971). Effect of organic manures on fertility as shown by nutrient availability and yield response in potato. *Proc. Int. Symp. Soil Fert. Evaln.* (Vol. 1), N.Delhi, pp. 815-820

Singh, K. and Singh, S. (1990) Effect of preceding rotation crops and levels, levels of nitrogen and phosphorus on the yield and economic returns of wheat. *Haryana J. of Agron.* **6** (1):1-7

Singh, K.N. and Deka, J. (1990) Integrated Nutrient Supply System for Sustainable Crop Production. In : Agron. Res. Towards Sustainable Agric. Eds. Singh, K.N. and Singh, R.P., *Ind. Soc. of Agron.* N. Delhi. pp-35-56.

Singh, K; Taneja, K.D.; Gill, P.S. and Thareja, S.K. (1981) Effect of preceding crops and levels of nitrogen on forage yields of chinese cabbage (*B. pekinensis*). *Journal of Res.*, H.A.U., Hissar **11**: 49-63

Singh, R. (1992) Integrated nutrient supply system in wheat and wheat based cropping systems. *Fert. News.* **37** (4): 35-74

Singh, R.P.; Das, S.K.; Rao, B. and Reddy, M.N. (1990) Towards sustainable dryland agricultural practices. CRIDA, Hyderabad

Singh, R.P.; Prasad, R.N.; Sinha, H. and Singh, K.D.N (1979) Rate of organic amendments on Zn availability to maize and soybean in calcareous soil. *J. Ind. Soc. Soil. Sci.* **27** (3): 321-324

Singh, V.; Kumar, R. and Lakhan, R. (1994) Effect of applied farmyard manure and molybdenum on yield and nutrients uptake by Egyptian clover (*Trifolium alexandrinum*). *Ind. J. Agron.* **39** (3): 507-509

Singh, V.K and Bajpai, R.P (1990) Effect of phosphorus and potash on the growth and yield of rainfed soybean. *Ind. J. Agron.* **35** (3) : 310-311

Singh, V.P. (1999) Effect of organic and inorganic source of nutrients on fingermillet (*E. coracana*) under rainfed low hill situation. *Ind.J.Agron.* **44** (3): 567-570

Singh, Y.; Singh, P.P. and Singh, D. (1994) Response of soybean (*G. max*) to nitrogen, phosphorus and potassium fertilizers in Kumaon hills of U.P. *Ind. J. Agron.* **39** (4): 680-681

Snedecor, W.G and Cochran, W.G (1967). Satistical methods (VI Edn.). The Iowa State Univ. Press. Iowa, USA. pp. 593 + xiv

Soni, K.C. and Gupta, S.C. (1999) Effect of irrigation schedule and phosphorus on yield, quality and water-use efficiency of summer mungbean (*V. radiata) Ind. J. Agron.* 44 (1): 130-133

Srinivasan, K. and Ramasamy, M. (1992) Effect of foliar nutrition of urea and diammonium phosphate on rainfed cowpea (*V. unguiculata*). *Ind. J. Agron.* 37 (2): 265-267

Srivastava, G.P. and Srivastava, V.C. (1993) Nitrogen economy and productivity of wheat succeeding grain legumes. *Ind. J. Agric. Sc.* 63 (11): 604-608

Srivastava, S.L.N and Varma, S.C. (1982) Effect of bacterial and inorganic fertilization on growth, nodulation and quality of greengram. *Ind. J. Agrl. Res.* **16** (4): 223-224

Srivastava, S.L.N. and Varma, S.C. (1981) Effect of biological and inorganic fertilization on the yield and yield attributes of greengram. *Ind. J. Agrl. Res.* **15** (1): 25-29

Srivastava, S.L.N. and Verma, S.C. (1982) Effect of bacterial and inorganic fertilization on growth, nodulation and quality of greengram. *Ind. J. Agrl. Res.* **16** (4):223-229

Studies on INM in *kharif* in sorghum in transitional tract. M.Sc. Thesis submitted to the Univ. of Agric. Sci., Dharward.

Subbarao, N.S. (1983) Phosphate solubilization by soil microorganisms. In: *Advances in Agric. Microbiol.* (Ed. N.S.Subbarao) Oxford and IBH, N.Delhi, pp. 295-303

Subbian, P. and Palaniappan, S.P. (1992) Effect of integrated management practices on the yield and economics of crops under high intensity multiple cropping systems. *Ind. J. Agron.* 37 (1): 1-5

Subbian, P. and Palaniappan, S.P. (1992) Effect of integrated management practices on the yield and economics of crops under high intensity multiple cropping systems. *Ind. J. Agron.* 37 (1): 1-5

Suri, V.K.; Jha, S. and Verma, T. S. (1997) Efficient and economic fetilization of rainfed maize for its specific yield through soil testing and INM. *Crop Res.* Hissar. **13** (1): 59-67

Swaminathan, M.S. (1990). Foreword. In Proceedings of 1st International Symposium on Natural Resources Management for Sustainable Agriculture. pp. i-iv.*Indian Society of Agronomy.*

Swaminathan, M.S. (1996). *Survey of Ind.Agric.*, The Hindu. pp.29-33

*
Swindale, L.D. (1990). Research on sustainability in the International Agricultural Research Centres. Sustainable Agriculture – Issues, Perspectives and Prospects in Semi-Arid Tropics.Vol.I. *Proceedings of I International Syposium on Natural Resource Management for Sustainable Agriculture.* pp.1-16 Indian Society of Agronomy.

* Swaminathan, M.S. (2000). For an evergreen revolution. In The Hindu Survey of Indian Agriculture 2000. pp. 9-15, The Hindu

TAC (Technical Advisory Committee of the Consultative Group on International Agricultural Research). (1989). Sustainable agricultural production for international agricultural research. *FAO Research and Development Paper. pp.131.*

Takkar, P.N. (1996) Micronutrient research and sustainable agicultural productivity in India. *J. Ind. Soc. Sci.* **44** 944):562-581

Talashilkar, S.C.; Dosani, A.A. K.; Mehta, V.B and Powar, A.G. (1997) Integrated use of fertilizers and poultry manure to groundnut crop. *J. Maharashtra Agric. Univ.* **22** (2): 205-207.

Tandon, H.L.S (1990) Integrated nutrient management for sustainable dry land agriculture. Sustainable Agric. – Issues, Perspectives and Prospects in Semi-Arid Tropics. Vol. I Proc. I[st] Int. Symp. on Nat. Resources Management for Sustainable Agric. pp 203-222

Tandon, H.L.S. (1978) Fertilizer use under different soil cropping system. Lecture for the 20[th] Short Course in Soil Testing, I.A.R.I., N.Delhi, Nov. 1978.

Tandon, H.L.S. (1980) Soil fertility and fertilizer use on wheat in India. A review. *Fertiliser News* **25**: 45-78

Tandon, H.L.S. (1990) Fertilizers and Sustainable Agric. In: *Soil fertility and fertilizer use.* Vol. IV. IFFCO Ltd.

Tandon, H.L.S. (1995) Trends in Integrated Crop Rotation, *Survey of Ind. Agric.*, The Hindu., pp-149-151.

Thakur, K.S. and Chand, J. (1998) Response and economics to nitrogen and phosphorus nutrition in *gobhi sarson* (*B.napus subsp. oleifera,* var. *annua*) under rainfed conditions. *Ind. J. Agron.* **43** (4): 733-737

Thimme Gowda, S. (1983) Nitrogen nutrition to greengram. *Acta Agronomica* **32**: 139-142

Tiwana, U.S.; Narang, R.S. and Gosal, K.S. (1999) Nutrient management for yield maximization of rice (*O. sativa*) – wheat (*T. aestivum*) cropping system. *Ind. J. Agron.* **44** (1): 1-7

Tomar, S.; Tomar, S. and Singh, S (1992) Effect of irrigation and fertility levels on growth, yield and quality of mustard (*B. juncea*) *Ind. J. Agron.* **37** (1): 76-78

Tomar, S.S.; Abbas, M.; Singh, T. and Nigam, K.B. (1994) Effect of phosphate-solubilizing bacteria and phosphate in opium poppy (*Papaver somniferum*). *Ind. J. Agron.* **39** (4): 713-714.

Tomar, S.S.; Pathan, M.A.; Gupta, K.P. and Khandkar, U.R. (1993) Effect of phosphate-solubilizing bacteria at different levels of phosphate on blackgram (*V. mungo*). *Ind. J. Agron.* **38** (1): 131-133

Tomar, T.S.; Kumar, S.; Tomar, S. and Singh, S (1997) Response of Indian mustard (*B. juncea*) to N, P and S fertilization. *Ind. J. Agron.* **42** (1): 148-151

Toor, G.S and Bahl, G.S. (1999) Kinetics of phosphate desorption from different soils as influenced by application of poultry manure and fertilizer phosphorus and its uptake by soybean. *Bioresource Tech.* **69** (2): 117-121

Tuivavalagi, N.S. and Silva, J.A. (1996) The effect of chickenanure and inorganic fertilizers on soil properties and the growth and yield of ıze (*Zea mays*) grown on a Hawaiian oxisol.

Vara, J.A.; Modhwadia, M.M.; Patel, B.S.; Patel, J.C. and nanpara, V.D. (1994) Response of soybean (*G. max*) to nitrogen, phoıorus and *Rhizobium* inoculation. *Ind. J. Agron.* 39 (4):678-680

Vasilas, B.L.; Legs, J.O. and Wolf, D.C. (1980) Foliar tilization of soybeans. Absorption and translocation of 15-N labelled urea. *Agn. Journal* **72**: 271-275

Verghis, T.I. (1996) Yield and yield development of chicea (*Cicer arietinum* L.) Ph.D. Thesis, Lincoln University, Canterbury, N.Zeald

Warren, W.S and Garry, L, (1985) Crop rotaions and ınure versus agricultural chemicals in dry land grain production. *J. Soil Water ɔns.* **40** (4): 511-515